EXPERIMENTAL HUSBANDRY FARMS

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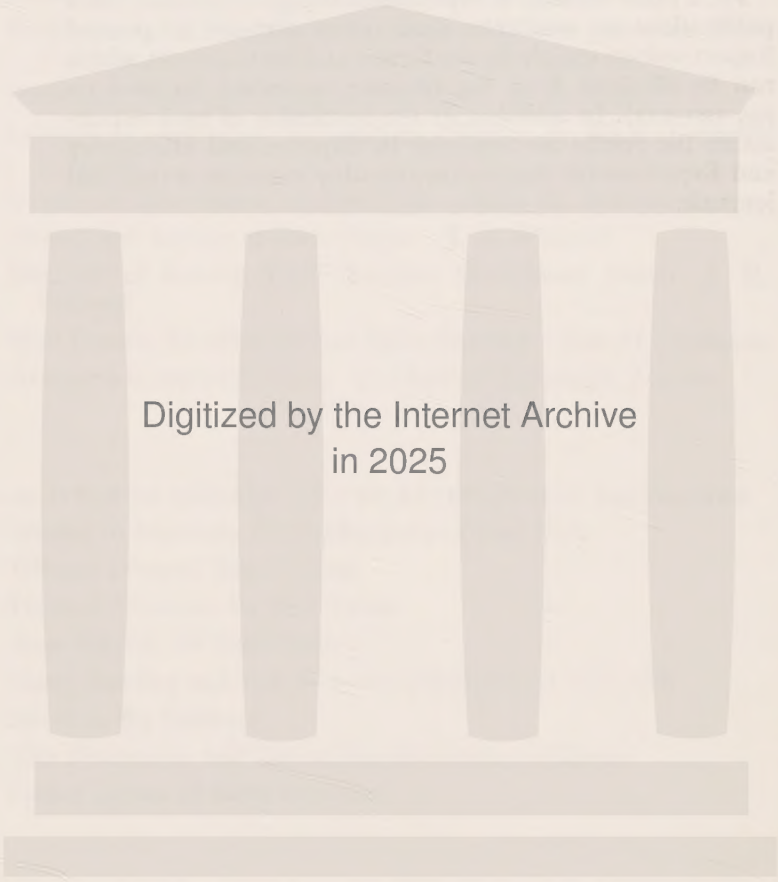
Introduction

This is the tenth Progress Report on experimental work at the N.A.A.S. Experimental Husbandry Farms and Horticulture Stations.

The Report does not attempt to review the whole field of investigations in progress in any one year but presents a selection of topics of particular interest, either because they are new to the experimental programme or because they have reached a stage where conclusions of practical importance can be reported.

For a fuller account of experiments being undertaken, other publications are available. Each centre prepares an Annual Report written mainly for the farmer and horticulturist, which can be obtained from the Director concerned (address on pp. 120–122). In addition, at the conclusion of most experiments the results are reported in Experimental Husbandry and Experimental Horticulture or other scientific or technical journals.



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Results from Recent Experiments

INTENSIVE CEREAL CROPPING

E. J. Mundy, *Norfolk Agricultural Station*

Over the past ten years the acreage of wheat and barley grown in England and Wales has increased by almost 3 million acres. This figure represents an increase of approximately 66 per cent over that grown annually during the period 1956–58. Agricultural Statistics show that changes in wheat and barley acreage have not been confined solely to the arable counties of Eastern and Southern England. In fact many of the Western counties show a similar proportional growth of barley. Much of the growth in cereal acreage has been due to the rapid expansion of barley, nevertheless there has also been a small increase in the area of wheat.

The acreage of wheat and barley grown reflects the trend of intensive cereal cropping that has been adopted on many farms and in 1967–68 almost two-thirds of the arable land in some counties carried wheat or barley. The practice of growing longer runs of cereals, particularly barley, has become common and a number of fields are now being continuously cropped with barley. The practice is not altogether of recent origin and has been carried out successfully for a number of years. An experiment on continuous barley growing at High Mowthorpe E.H.F. has shown that the yield of barley can be maintained at a satisfactory level provided the standard of husbandry is high and adequate fertilizer is given. Over the past three years a yield of a little over 35 cwt has been achieved from the 13–15th successive crops where 125 units of nitrogen have been given. This level of yield has been similar to that obtained in a rotation where barley was grown every second year. However, the level of nitrogen for rotational barley has been less, being only 50 units after a legume crop or 75 units after a root crop.

At Boxworth it has been possible to maintain a satisfactory yield of winter wheat on one field where continuous cropping with wheat has been practised. Over the years 1966–68 a mean yield of 34 cwt has been achieved for the 15–17th crops, in each year the crop received fertilizer supplying from 120 to 140 units of nitrogen.

Co-ordinated Trials

In 1962 and 1963 trials were commenced at six Experimental Husbandry Farms and at the Norfolk Agricultural Station to study the effect intensive cereal growing has on plant health, weeds, soil fertility and crop yield. The trials were all of a similar type and were designed to bring land into intensive cereal cropping after at least a two-year break from wheat or barley. Over the past five or six years duplicate plots of land on each site were brought into continuous cereal cropping each year. In 1968, the sixth year of the trial at all but one farm, each site carried a full range of successive cereal cropping from a first crop, to a sixth successive crop, after the break. All cereals received four rates of nitrogen fertilizer in order to determine the crop requirement for nitrogen under a system of successive cropping. On three sites winter wheat was grown, on another three sites

TABLE 1

Intensification of cereals: site details

Crop	Winter wheat			Spring wheat	Winter barley	Spring barley		
Farm	Boxworth	High Mowthorpe	Rosemaund	Bridget's	Norfolk Agric. Station	Bridget's	Gleadthorpe	Trawscoed
Soil	calcareous clay	chalky silty loam	stoneless silty loam	chalky silty loam	sandy loam	chalky silty loam	loamy sand	silty loam
Variety	Cappelle Desprez	Cappelle Desprez	Cappelle Desprez	Opal/Kloka	Maris Otter	Proctor/ Impala	Rika/Impala	Rika/Impala
Nitrogen range (Units/ac)	30–120	40–160	30–120	0–100	20–80	0–90	30–150	0–90
Preceding break crops: (1)	beans	ley	beans	kale	sugar beet	kale	sugar beet	potatoes
(2)	oats	ley	oats	oats	potatoes	oats	oats	oats

spring barley was sown and winter barley and spring wheat were sown on one site each. The details of cropping and nitrogen fertilizer for each site are given in Table 1.

Results

Since the trials described are still in progress and data on the effects of successive cropping are limited to a few years the results presented should be considered as interim only.

Yield of grain

Yield data for the second and subsequent crops after the break, presented in Tables 2 to 5, have been expressed as a percentage of the yield obtained from the first crop after the break. This method of presentation partly overcomes the effect of seasonal variation and the variable number of harvest years that are meaned to give the average for a specific crop. The method also gives some information on the trend in yield that has occurred in the trials.

Table 2

Yield of wheat at optimum rate of nitrogen for 1st crop after break (yield of 2nd and subsequent crops expressed as percentage of 1st crop)

Year of crop after break Harvest years		1 1963–8	2 1964–8	3 1965–8	4 1966–8	5 1967–8
Site	Units N/ac	cwt/ac at 85% D.M.	%	%	%	%
Winter wheat						
Boxworth	60	40·6	94·4	82·9	73·7	74·6
High Mowthorpe	90	42·6	90·0	89·4	81·9	61·2
Rosemaund	30	41·5	82·5	53·0	72·9	69·9
Spring wheat						
Bridget's	80	28·6	82·7	68·9	62·4	69·5

Wheat

In Table 2 the optimum yield of wheat for the first crop after the break is given together with the yield data, as a percentage, for subsequent crops grown at the same nitrogen level. At all sites there has been a decline in yield over the first five years of cropping but the reduction varies between sites. On the stoneless silty loam of relatively poor structure at Rosemaund the fall was rapid over the first three years but thereafter some measure of recovery was apparent. At both Boxworth and High Mowthorpe the decline in yield was more gradual and at Boxworth appeared to have ceased in the fifth and sixth years. The effect of applying one increment of nitrogen to the second and successive crops of wheat is given in Table 3 and it is evident that at all three winter wheat sites this has reduced the loss. At Boxworth the application of an additional 30 units of nitrogen improved yields after the first crop and held yield level at approximately 80 per cent of the first crop. At High Mowthorpe the response was less marked but the

same trend was apparent, although in the fifth and sixth years the yield fell to 72 per cent of the first crop. At Rosemaund the response to nitrogen was apparent in the second crop and the fall in yield was reduced in succeeding crops.

TABLE 3

Yield of wheat: nitrogen rate one increment above optimum for 1st crop (yield expressed as percentage of 1st crop receiving optimum N)

Year of crop after break Harvest years		2 1964–8	3 1965–8	4 1966–8	5 1967–8
Site	Units N/ac	%	%	%	%
Winter wheat					
Boxworth	90	94·0	83·6	81·6	80·2
High Mowthorpe	120	88·0	86·5	84·7	72·4
Rosemaund	60	87·6	61·4	80·3	71·6
Spring wheat					
Bridget's	100	81·3	64·7	59·6	69·3

Spring wheat grown at Bridget's showed considerable variation in performance from one year to another and the optimum yield of the first crop was obtained using 80 units of nitrogen; unlike winter wheat, the response of second or subsequent crops to additional nitrogen was negligible.

TABLE 4

Mean yield of barley at optimum rate of nitrogen for 1st crop after break (yield of 2nd and subsequent crops expressed as percentage of 1st crop)

Year of crop after break Harvest years		1 1963–8	2 1964–8	3 1965–8	4 1966–8	5 1967–8
Site	Units N/ac	Cwt/ac at 85% DM	%	%	%	%
Winter barley						
Norfolk Agricultural Station*	40	34·9	89·6	87·6	77·8	75·9
Spring barley						
Bridget's	60	33·1	93·1	87·9	82·6	80·8
Gleadthorpe	90	33·0	87·1	83·6	78·0	82·3
Trawscoed	60	35·0	77·5	75·9	69·2	69·0

*Number of harvest years one less than at other centres.

Barley

The pattern of yield of spring barley was similar in many respects to that of winter wheat but the decline was generally not so great. Yield data at the level of nitrogen for optimum yield for the first crop is given in Table 4

while that obtained by increasing the nitrogen rate by one increment is given in Table 5. At both Bridget's, on chalky silty loam soil, and at Gleadthorpe on loamy sand, the additional nitrogen reduced the fall in yield in the second and third crops respectively and thereafter in subsequent crops. On the silty loam soil of Trawscoed, however, the decline was greater and additional nitrogen gave no benefit before the fifth year.

TABLE 5

Mean yield of barley: nitrogen rate one increment above optimum for 1st crop (yield expressed as percentage of 1st crop receiving optimum nitrogen)

Year of crop after break Harvest years		2 1964–8	3 1965–8	4 1966–8	5 1967–8
Site	Units N/ac	%	%	%	%
Winter barley					
Norfolk Agricultural Station*	60	93·1	85·9	84·1	70·0
Spring barley					
Bridget's	90	94·6	92·1	91·8	87·6
Gleadthorpe	120	93·0	90·6	84·1	81·0
Trawscoed	90	75·1	66·4	70·8	76·9

*Number of harvest years one less than at other centres.

Winter barley on the Norfolk Agricultural Station also showed a yield decline following successive cropping; the application of additional nitrogen gave a variable response suggesting that seasonal factors affected the response.

Application of nitrogen

Supplementary trials on successive crops of winter wheat at Boxworth and Bridget's suggest that the use of autumn nitrogen is of little benefit and the cost is unlikely to be justified if conditions at sowing are reasonably good. Work on these farms on time of application of spring nitrogen suggests that on the heavy soil at Boxworth two applications of nitrogen to winter wheat in early and late spring are preferable to a single application. Although seasonal differences occurred it was apparent that an early application of some of the nitrogen was necessary to encourage the crop to grow well in the spring. On the chalk loam soil at Bridget's the late application of all the nitrogen or a split dressing gave a better crop than a single early application. It would appear that the early application of nitrogen may result in increased lodging, thus seasonal effects of lodging may be accentuated. Studies at Bridget's also indicated that splitting the nitrogen for spring barley between the seed bed and an April top dressing resulted in better crops than where all the nitrogen was applied to the seed bed.

Disease

Two fungus diseases likely to increase in systems of intensive cereal production are take-all (*Ophiobolus graminis*) and eyespot (*Cercosporella*

herpotrichoides). However, incidence of take-all on continuous barley at High Mowthorpe, and on winter wheat at Boxworth (referred to in the introduction), indicates that a balance between the disease level and the crop may establish over a number of years. The co-ordinated trials and supplementary trials at Drayton, Rosemaund and Boxworth all indicate the very variable levels that can occur from one site to another and from one year to another. The levels of take-all infection at each site meaned over the past two or three years are presented in Table 6. A very high incidence of take-all was recorded on winter wheat at Rosemaund and in one year on spring barley at Trawscoed. It is probable that this high incidence contributed to the rapid fall in yield recorded at these sites. The level of take-all on spring wheat at Bridget's has also been high and here the crop has shown no response to increased nitrogen fertilizer application. At other centres the level of take-all has not been so high, but although root examination has not indicated severe infection, patches of stunted growth have been caused by the disease where fertilizer levels have been low and inadequate for strong crop growth. It is probable that root development has been encouraged by the application of additional nitrogen thus partially compensating for damage caused by the fungus. There are indications that although take-all may increase rapidly during the early years of continuous cropping, the level of infection may fall and stabilize over longer periods of cropping.

TABLE 6

Mean percentage plants infected with take-all
(at least 25 per cent root infection)

Site	Years meaned	Year of crop after break			
		1	2	3	4
Winter wheat					
Boxworth	3	3·4	17·9	29·6	18·9
High Mowthorpe	3	2·0	3·2	3·0	6·3
Rosemaund	2	14·6	26·9	69·1	59·4
Spring wheat					
Bridget's	3	6·1	47·6	68·9	72·6
Winter barley					
Norfolk Agric. Station	2	0·4	3·5	3·4	8·2
Spring barley					
Bridget's	3	1·7	6·3	20·6	26·4
Gleadthorpe	2	2·3	6·3	11·7	9·4
Trawscoed	2	39·3	35·3	48·4	49·5

The effect of eyespot on winter wheat has not been very pronounced. This was largely due to the choice of variety since Cappelle Desprez is fairly resistant to the fungus. Detailed examination has shown that the disease was present and data for the three winter wheat sites are given in Table 7. At all three sites the incidence of eyespot has increased with continuous

cropping and should a non-resistant variety be grown severe lodging and loss of yield would be likely to occur.

TABLE 7

Mean percentage tillers infected with severe eyespot

Site	Years meaned	Year of crop after break			
		1	2	3	4
Winter wheat					
Boxworth	2	4·5	9·5	8·1	17·2
High Mowthorpe	3	8·3	19·2	19·1	20·5
Rosemaund	2	6·9	7·9	5·3	8·5

At this stage, the effect of disease on crop yield in these trials has not been fully established but it seems likely that no single factor is the sole cause of the decline in yield that has been recorded.

Grain quality

Since the 1968 harvest most people have been aware of the effect season can have on quality and size of grain. Other factors also materially affect the size of grain, and the proportion of tail corn has been shown to increase with length of run of cereal cropping. Sieving tests were performed on the 1967 and 1968 grain samples from the trials at High Mowthorpe and Rosemaund and the results of these are summarized in Table 8. At both centres longer sequences of cereal cropping resulted in a larger proportion of small grain. At High Mowthorpe the proportion of tail corn over the first four years of cropping with 80 units of nitrogen remained fairly static but in the fifth year the proportion doubled. Over two years the mean level of take-all in the fourth crop was only 2·5, but it rose to 20·5 per cent in the fifth crop and patches of stunted growth occurred, thus suggesting that disease has a pronounced effect on grain size.

TABLE 8

Effect of continuous cropping on percentage weight of wheat passing through 2·4 mm. sieve (Mean 1967–68)

Site	Nitrogen Units/ac	Year of crop after break				
		1	2	3	4	5
High Mowthorpe	80	7·8	7·3	7·0	7·1	14·3
	120	10·0	9·9	11·3	15·1	15·7
Rosemaund	30	11·1	12·6	19·8	15·3	16·3
	60	15·9	16·4	24·5	19·5	20·4

At both farms it was apparent that higher rates of nitrogen fertilizer resulted in a larger proportion of tail corn, an effect that has been recorded in other trials.

Weeds

At most centres, where successive cropping with cereals has been practised, weed grasses have increased. Couch in continuous barley at High Mowthorpe and Trawscoed and in wheat at Boxworth has been particularly troublesome. Other grass species that have increased at some sites are rough stalked meadow grass and sterile brome grass, and in addition to grass weeds wild oats have been troublesome at Boxworth. Grass weed problems have always been most severe where crop vigour has been lacking and where fertilizer levels have been inadequate. In all instances cultural practices, combined in some cases with chemical methods, have kept the weed problems in check. Where fertilizer levels are adequate for good growth the problem has been much less severe.

Pests

The level of cereal cyst eelworm under the continuous cropping in the trials has been recorded but so far this has not proved to be of importance at most sites and little, if any, change in infestation has been noted. However, supplementary studies on loamy sand at Gleadthorpe show that on the lighter soils the danger of a build-up of eelworms must be taken seriously, and where continuous cereals are grown a check on the incidence of eelworms should be maintained.

Soil fertility and structure

Many of the trials in progress have not been running for sufficient years to detect any significant changes in the soil. At High Mowthorpe soil cropped with spring barley for twelve years retained an organic matter and nutrient status comparable to soil where barley was grown in alternate years with roots or clover. On soils with a structure problem continuous cereal cropping could possibly accelerate the loss of structure and result in practical difficulties and lower yields.

Conclusions

Continuous cropping with wheat or barley has resulted in a decline in yield but reasonably satisfactory yields have been maintained in most instances. The problems associated with the growing of long runs of spring barley appear less serious than those with winter wheat. Where successive cropping of wheat or barley occurs, it is essential that fertilizer levels should be fully adequate for growth and the overall standard of husbandry must be high. Nitrogen fertilizer requirement has been shown, in many cases, to be higher for the third or fourth crops than for the first and second crops after a break, and overall yield and gross margin will almost certainly be less than that from a first crop. Grass weeds have often been a problem and early measures to control them have been necessary. Weeds, together with a rise in incidence of disease, have probably contributed towards the falls in yield recorded in continuous cereal cropping sequences.

The investigation of problems associated with intensive cereals continues. Additional trials have recently been started to determine the short and

long term effects of a break crop grown in intensive cereal systems. The break crops are aimed at controlling the build up of weeds, diseases and pests, while maintaining or improving soil fertility.

WHOLE CROP CEREALS FOR SILAGE

M. Selman, *Boxworth Experimental Husbandry Farm*, in collaboration with G. Alderman and W. H. Helme, *N.A.A.S., S.E. Region*

Cereals have been used as a major ingredient of arable silage for over a hundred years. The current interest is in direct cutting at a more mature stage than hitherto and was stimulated by some farmers who started to ensile whole crop barley in tower silos.

Tower silos need to be filled with materials whose dry matter content approaches 40 per cent to avoid effluent and to ensure easy mechanical loading and unloading. If grass is used, it will probably need to be wilted for up to two days after cutting if a sufficiently digestible crop is to reach this degree of dryness. Compared with direct cutting, this causes extra work and can result in quite large field losses as reported by Mair in *Progress Report* 1968 (Silage making in towers and clamps, pp. 9–15).

The problems of weathering during the wilting of grass for silage and curing grass for hay, resulting in somewhat variable quality in the end products, has led some farmers to straw plus balancer (often largely barley) systems of feeding. The use of whole crop cereals cut in mid-July at the doughy grain stage for silage, appears to be a logical development which overcomes the problem of wilting grass and avoids the separation of grain and straw.

The Plant Breeding Institute at Cambridge had been studying the annual output of digestible dry matter from various crops for several years, when in 1965 extended investigations were simultaneously initiated there, at the Grassland Research Institute and at Bridget's E.H.F. Results were encouraging, whole crop cereals cut direct showing that:

the level of dry matter output obtained from one cut almost equalled the yield given by several cuts of heavily manured grass;

there was a fairly consistent level of digestibility of about 60 per cent DOMD when the crop was at a dry matter content suitable for ensiling (in July);

this level of digestibility was maintained for several weeks by an increase in the highly digestible grain fraction compensating for the deterioration in feeding quality of the straw, as the crop began to ripen.

Other advantages have at various times been claimed in addition to these, e.g.,

trouble-free fermentation;

low labour and machinery requirements for cutting and storage;

a reduction of the acreage taken for grass silage in early summer and hence a reduction of the peak demand for labour and machinery at that time.

land can be made available for cleaning or re-planting from mid-July;

about two weeks are available for harvesting in July without deterioration of the crop.

Three disadvantages have emerged:

lower annual DM yield than from good well-fertilized grass;
lower digestibility and lower crude protein content than in grass;
whole crop cereals are not a break crop for intensive cereal growers.

In 1966 the work at Bridget's E.H.F. was continued, and trials to assess crop yield and quality together with harvesting and storage studies commenced at Boxworth E.H.F. and Gleadthorpe E.H.F., where a feeding trial with beef cattle was also carried out. Harvesting and storage studies were extended to High Mowthorpe in 1967, and in the following winter feeding trials commenced with milking cows at Bridget's and with beef cattle at High Mowthorpe. More recently investigations have also been carried out by Liscombe E.H.F. and the Welsh Region to obtain data applicable to the wetter parts of the country.

Growing the Crop and Yields of Dry-Matter

Most of the trials were carried out on commercial crops of barley, but there were also some on commercial crops of wheat and oats. In addition, there were trials drilled specifically to compare different varieties and crops. Different cutting dates and rates of nitrogen fertilizer application were also compared. Cuts were usually made at intervals during July, and the nitrogen rates compared were in the 60–160 units per acre range.

In general it has been found that the fertilizer requirements for growing cereals for silage are similar to those for grain crops, and that varieties which have a good grain yield potential give a reasonably digestible silage.

Best yields of dry matter (cwt per acre, mean of all N rates) and dates on which they were recorded

Crop and centre		1966	1967	1968	Mean
Spring barley	Boxworth (Impala)	76·4 20 July (60·0–80·5)	64·5 11 July (63·1–68·0)	89·8 2 August (63·1–91·0)	76·9
	Bridget's (Various)	76·7 1 August (55·8–76·7)	72·3 10 July (64·6–82·4)	65·4 9–20 July (field yield)	71·5
	Gleadthorpe (Various)	57·6 27 July (41·5–62·3)	48·2 11 July (33·7–56·2)	68·2 17 July (53·5–77·4)	58·0
Spring oats	Boxworth (Condor)	—	83·4 31 July (59·1–83·8)	83·6 2 August* (56·3–88·5)	83·5†
Winter wheat	Bridget's (Cappelle)	75·5 1 August (50·8–75·5)	92·4 31 July (79·0–93·9)	64·0 8 July (field yield)	77·3

Figures in brackets give the range of yields in each season at a particular centre over all nitrogen levels and dates of cutting.
* Crop suffered considerable thinning after sowing.
† Mean of two years only.

Dry matter at harvesting (percentage)

Crop and centre		1966	1967	1968	Mean
Spring barley	Boxworth	35 (27–48)	33 (31–61)	37 (25–37)	35
	Bridget's	54 (25–54)	35 (34–51)	29–37	41
	Gleadthorpe	45	43 (42–74)	26 (19–35)	38
Oats	Boxworth	—	44 (26–46)	28 (17–29)	36
Winter wheat	Bridget's	47 (33–53)	46 (37–47)	33	42

Figures in brackets give the range of values obtained.

Best yields of dry matter have seldom been obtained from crops containing less than 35 per cent dry matter, although in wet seasons or high rainfall areas this did occur. In some cases higher yields have been obtained by allowing the crops to become rather more mature, i.e., approaching 50 per cent DM. However, in normal years the dry matter content changes very quickly after 40 per cent and crops may rapidly become too mature for satisfactory ensiling. In many seasons the period which the crop is at the best dry matter content (37–43 per cent) for storing in tower silos may only amount to some ten days.

The effect of rates of fertilizer nitrogen on dry matter yield has not been consistent. The requirements for whole crop barley are broadly similar to those for a crop left for grain. This may not apply in the wetter parts of the country: barley at Liscombe tended to respond to 120 units N and barley at some Welsh farms to 80–90 units N per acre in 1968. At Boxworth oats have responded to about 100 units in the past two years.

Nutritive Value At Harvest

Crude protein levels for barley, wheat and oats have seldom exceeded 10 per cent in the dry matter. Seasonal variations in protein contents have been noted, and the effect of fertilizer nitrogen rates on crude protein levels have been consistent. These effects can be quite marked, e.g., at Gleadthorpe in 1967 increasing the nitrogen rate from 60 to 140 units per acre raised the mean crude protein level from 5·6 to 8·2 per cent.

One of the most important features of whole crop cereals is claimed to be a predictable level of digestibility which does not change much during July. Results from the trials confirm this on the whole, but there have been notable cases of digestibility being well below 60 per cent. At Boxworth, values for barley in the last two years have been nearer 50 per cent DOMD. There was undoubtedly an influence from wild oat contamination in these

results. At Gleadthorpe in 1968 there was a marked drop in digestibility after the first cut on 4 July which was due to severe lodging. Much grain was lost as whole heads were left unharvested on the ground. This again emphasizes the importance of the grain fraction in maintaining good digestibility levels. If crops conserved have only a low potential grain yield, digestibility as well as total yield of dry matter will suffer.

Digestibility value of best DM yield (DOMD percentage)

Crop and centre		1966	1967	1968	Mean
Spring Barley	Boxworth	62 (57–66)	52 (49–55)	52 (49–55)	55
	Bridget's	61 (56–63)	56 (52–59)	55–57	58
	Gleadthorpe	66 (60–68)	65 (59–67)	41 (37–58)	57
Spring oats	Boxworth	—	49 (45–53)	44 (37–51)	47
Winter wheat	Bridget's	65 (61–65)	57 (55–59)	56 (54–58)	59

Figures in brackets give the range of values obtained.

Whole crop winter wheat has shown up well in comparison with barley in terms of digestibility, but whole crop oats have not. Digestibility values for oats have generally been below 50 per cent rather than above. In 1968 this low digestibility was a feature of oats even when cut at dry matter contents of 17–25 per cent.

Field-Scale Harvesting and Storage

Fifteen field scale cuts have been made during the past three years on five farms. Six of these entailed using a direct-cut, metered-chop machine (one self-propelled and five tractor-drawn, metered-chop harvesters, with cutter bar attachments). In all cases, speed of work, shortness of chop, and field losses were satisfactory. Four cuts (one each of oats and barley, two of wheat) were made using a mower, rowing up the crop, and picking up with a tractor-drawn, metered-chop harvester. The chop was good with wheat and oats but rather long with barley. Three barley crops were cut direct by flail harvester, but this method proved to be slow, the chop was long, and the material did not consolidate well. When used after a mower in a further two cuts, the flail harvester caused considerable grain losses in oats and barley.

Harvesting and storage has been carried out at Bridget's E.H.F. using a tractor-operated full-chop machine. Requirements for man and tractors hours for harvesting were as follows:

		Grass silage 1st cut in tower	Barley silage in tower	Barley silage in clamp
1967	Yield in cwt DM/ac	34·0	68·6	—
	Man hrs/ton DM	3·6	1·5	—
	Tractor hrs/ton DM	4·3	1·8	—
1968	Yield in cwt DM/ac	27·0	66·0	65·4
	Man hrs/ton DM	4·9	2·1	3·2
	Tractor hrs/ton DM	4·8	2·2	3·4

Taking all the farms together, harvesting has been carried out at dry matter contents varying from 29–45 per cent. Cuts for bunker silos were best made at the lower end of the range quoted as consolidation was better. For tower silos dry matter contents of over 35 per cent were desirable to avoid effluent. At over 45 per cent the awns in barley may cause intake problems with stock, and even when short chopped, the material may suffer moulding.

Amounts of fresh material ensiled have varied from 29 tons off about 5 acres in a vacuum pack at Liscombe, to 33 tons in bunkers and 126 tons in a sealed tower silo at Bridget's E.H.F. Fermentation has normally been good in bunker silos, although at Gleadthorpe flail-cut material deteriorated after opening and storage losses were high at 33 per cent. There have also been instances of heating at the top of bunker silos. Losses have also been as low as 12·7 per cent in bunkers. By comparision dry matter losses in a small silo at Boxworth with flail-cut material were 15 per cent. Short chopped material in tower silos has been subject to a dry matter loss of only $6\frac{1}{2}$ per cent at Bridget's E.H.F. but up to 17 per cent at High Mowthorpe. Fermentation in tower silos has been good, except for flail-cut material at Boxworth in 1968, some overheating in the top of the tower at Bridget's in 1967, and also in a small amount of immature wheat (used for topping-up a silo) which became butryic at High Mowthorpe. The typical fermentation in tower silos has produced a predominantly lactic acid type of silage with only a slightly acid smell.

Crude protein contents of crops at ensiling have been: barley 7·4 to 9·1 per cent, wheat 7·0 to 7·2 per cent. Oats on removal from the silo contained 8·7 per cent, but for all crops crude protein levels have been up to 2 per cent higher in the silage as fed than in the material ensiled.

In vitro digestibility values (DOMD) for barley as ensiled have varied from 51 to 65 per cent, but have usually been about 55 to 58 per cent. Wheat crops have varied from 55 to about 60 per cent, but oats have been as low as 48 per cent.

Feeding Trials

There have been no feeding trials at Boxworth but whole crop barley silage has been compared with grass silage, grass silage plus straw, and straw plus balancer for dairy cows at Bridget's in 1967; and with straw plus dried grass

at Bridget's in 1968. Results for 1968 are not yet available. The results for the comparison with grass silage in 1967 are tabulated below.

Barley silage for dairy cows

Silage	lb DM fed as silage	*in vivo* DOMD %	Balanced concentrates lb DM	Barley & minerals lb DM	Milk yield gal/day	BF %	SNF %	Liveweight change lb/day
Barley	20·7	62	9·6	—	3·2	3·75	8·61	+0·30
Grass	20·6	61	—	8·3	3·1	3·92	8·62	+0·05

Barley silage was thought capable of producing maintenance plus one gallon of milk, and grass silage maintenance plus one and a half gallons. In fact, rather more concentrates than this would imply were fed to both groups. Whereas grass silage only required barley and normal dairy minerals to meet the cows' nutritive requirement, the barley silage required a normal 16 per cent protein concentrate and a special mineral supplement containing sodium, magnesium and manganese.

At High Mowthorpe in exploratory trials, and at Gleadthorpe in an observation study, disappointing results have been obtained with 12–14-month-old beef cattle weighing about 7 cwt.

At High Mowthorpe

Trial 1. *Hereford x Friesian Steers* (25 *per treatment*) 1966/67: 44 *days*

Silage	Dry matter intake (lb per day)		Daily liveweight gain lb		Mean
	(a) with 3½ lb oats/day (for 30 days)	(b) with 7 lb oats/day (for 14 days after (a))	with 3½ lb oats	with 7 lb oats	
Wheat	10·6	7·7	1·53	0·78	1·30
Grass	11·8	10·2	1·60	2·78	2·00

Trial 2. *Friesian Steers* (6 *per treatment*) 1966/67: 33 *days*

Silage	Concentrates lb	Dry matter intake (lb/day)	Daily liveweight gain lb
	3½ Oats	17·3	0·8
Wheat (ex tower)	7 Oats	11·8	1·6

Trial 3. *Friesian Steers* (12 *per treatment*) 1967/68: 28 *days*

Silage	Concentrates lb	Dry matter intake (lb/day)	Daily liveweight gain lb
Oat (ex tower)	3½ Oats	17·0–17·5	1·21
	7 Oats	12·7–15·3	1·61
	7 Oats/beans	13·5–14·4	1·61

At Gleadthorpe

Friesian Steers (8 *per treatment*) 1966/67: 91 *days*

Silage	Concentrates	Dry matter intake per day	Daily liveweight gain
Barley (ex bunker)	4 lb Rowett mixture	16·4 lb	1·7 lb

Improvement in rate of liveweight gain per day occurred on two occasions out of three as a result of increasing the quantity of supplementary concentrates fed, but at the same time the intake of whole crop cereal silage was reduced. By comparison, intakes of grass silage were not reduced, and liveweight gains from grass silage plus 7 lb cereals reached the target of 2 lb liveweight gain per day at High Mowthorpe. Gleadthorpe also normally expect to achieve 2 lb per day with good grass silage and 7 lb Rowlett ration.

Whereas the silage fed at Gleadthorpe was 62 per cent DOMD, and of similar digestibility to most of their grass silage, the wheat silage at High Mowthorpe was about 10 units lower in digestibility than the grass silage.

Economic Evaluation as a Feed for Dairy Cows

One way of costing whole crop cereal silage is to consider that the crop is grown with the option of harvesting it as grain, but is, in fact, used for silage at an immature stage. There are harvesting costs with either method of disposal but the cost of cereal silage can be regarded as being the opportunity cost of the grain crop which could have been sold. As such it is a method of buying winter forage and the cost may be compared with other alternative ways of supplying this.

By taking the three-year mean of best annual yields of dry matter for Boxworth and Bridget's and allowing an assumed in-store loss of 13 per cent and 6½ per cent respectively, the acreage to supply a cow with 20 lb DM per day for 185 days and cost per cow work as follows:

Acreages to feed a cow and opportunity cost of whole crop cereals

	Boxworth		Bridget's	
	Barley	Oats	Barley	Wheat
Yield DM cwt/ac	76·9	83·5	71·5	77·3
Acres required per cow per winter	0·49	0·45	0·50	0·46
*Yield of grain/cwt/ac	31·9	41·0	33·1	31·7
Value of grain/ac	£26·4	£51·3	£37·7	£37·3
Calculated cost per cow	£18·0	£23·3	£18·8	£17·1

*Not farm average, but grain yield expected when crops are grown under similar conditions to those in which the whole crop cereal yields were obtained.

Alternatively, the crop may be evaluated as being grown as part of the forage necessary for the winter feeding of livestock. As such there would be no opportunity value. The variable costs of growing the cereals are added to the other forage variable costs of the livestock to which they are fed and the acreage used for whole crop cereals included in the forage acres per cow.

At Bridget's in 1967 the whole crop system has only been followed right through one complete year, from harvesting to feeding dairy cows. Further information will soon be available. The evaluation set out below is a specimen based on 1967 data only. In that year 3·8 tons DM were obtained from grass and 3·4 tons DM from barley.

Acreage Used per cow

	Silage	Grazing	Total forage acres
Grass silage	0·45	0·45	0·90
Barley silage	0·50	0·45	0·95

Variable costs

	Seed cost	Fertilizer	Total per acre
Grazing	33/–	200/–	233/–
Barley silage	32/–	113/–	145/–
Grass silage	33/–	158/–	191/–

Variable costs of forage per cow

	Grazing	Silage	Total
Grass silage	105/–	86/–	191/–
Barley silage	105/–	65/–	170/–

Figures for Margin over Concentrates calculated from the results of the feeding trial and assuming September calving are:

Margin over concentrates

	Grass silage	Cereal silage
	£	£
Winter milk	107·2	105·6
Summer milk	48·1	48·1
Total sales	155·3	153·7
Concentrates (including barley)	32·3	38·3
Margin over concentrates per cow	123·0	115·4

Calculation of margin over concentrates and forage variable costs

	Acres	Margin over concs. per cow	Margin/cow over concs. + forage variable costs per cow	Margin over concs. + forage variable costs per acre
		£	£	£
Grass silage	0·90	123·0	113·4	126·0
Cereal silage	0·95	115·4	106·9	112·5

In this evaluation grass used for silage only, with no grazing, is compared with whole crop cereals, and the comparision is clear cut, particularly as annual yields of DM were similar. In many instances whole crop cereals would be fitted into more complicated grazing plus conservation systems.

In addition to differences in variable costs between grass and barley silage systems, any likely impact on fixed costs caused by a change from one system to another must be taken into account. For whole crop cereals a direct cutting head is used on the forage harvester rather than the pick-up attachment used for grass silage, but grass silage requires a mower and crimper. The requirement for tractor and man hours is similar from the point at which the crop is picked up into the trailer: overall figures for tractor and man hours in 1967 and 1968 have been quoted earlier.

Summary and Conclusions

Levels of potential yield as assessed from plot trials at Boxworth and Bridget's, are between 3 and 4 tons dry matter per acre but at Gleadthorpe are usually below 3 tons per acre. Yields from winter wheat can be higher than those obtained from barley and this crop is sometimes easier to handle (High Mowthorpe). Oats can give rather higher yields of dry matter than barley but at the expense of a lower digestibility. For bunker silage the material should be cut at a lower moisture content than for tower silage if overheating is to be avoided. If oats are deemed desirable because of considerations of cereal rotation they may be more suited to ensilage in a bunker.

Levels of crude protein are low compared with grass silage but can be raised to some extent by the use of larger amounts of nitrogen fertilizer. The use of more than 60 units nitrogen per acre did not consistently increase dry matter yields.

The annual output of dry matter is often less than can be obtained from several cuts of well manured grass and digestibility will also be lower than from correctly managed grass, but may be similar to that of much conserved grass, especially in seasons when weather is bad. Annual output from the system could be increased by catch-dropping, or use made of the time when the crop is not growing for cleaning or early sowing of subsequent crops. Much larger quantities of material are obtained from a single cut than is usually the case with grass. The season for cutting whole crop cereals does not interfere with other farm operations such as cereal harvest or grass silage making.

The use of a metered-chop forage harvester enables a palatable silage

with good fermentation characteristics to be produced; there may be some expenses in acquiring attachments for direct cutting, but there is a saving in requirements for conditioning machinery. Discussion of the digestibility levels of whole crop cereals for silage have been left until last because it is likely that this is the most important aspect of this feed. Intensive production systems for fattening cattle require a food with a high level of digestibility if fed alone. Whole crop cereal silage alone will not provide a sufficiently digestible ration for beef animals and appreciable quantities of concentrates will be required to achieve a sufficient rate of liveweight gain.

Fodder digestibility levels from 55–60 per cent may however be quite sufficient for milking cows provided that adequate concentrates are used. Whole crop cereal silage would therefore appear to be suitable for cows.

The foregoing suggests that the use of whole crop cereals as a source of feed for livestock enterprises, other than the more intensive systems of fattening cattle, appears to have possibilities as a useful alternative or adjunct to grass conservation.

MINIMUM LABOUR SUGAR BEET ON SAND AND PEAT SOILS

R. Wickens, *Arthur Rickwood Experimental Husbandry Farm*
L. W. Wellings, *Gleadthorpe Experimental Husbandry Farm*

Sugar beet is a most important cash crop on both Gleadthorpe and Arthur Rickwood Experimental Husbandry Farms. There are highly contrasting soils on the two farms; at Gleadthorpe it is a stony sand, often in sloping fields and with an inherently low pH, P and K status and water-holding capacity. At Arthur Rickwood the fields are level and the peaty-loam soil is more alkaline, highly fertile and of greater water-holding capacity. Soils on both farms allow easy preparation of spring seedbeds even after late ploughing but their friable natures make them susceptible to soil blowing. Late frosts can also be a hazard.

The differences in the composition of the soils leads to well-known differences in their reaction to soil-acting herbicides. On the sandy soils immediate activity is high and crop damage can result if critical dose rates are exceeded, but, because of the low humus content, herbicides are easily leached from the activity zones and their persistency is low. On the peaty soils activity is considerably lowered at all stages by the rapid adsorption of the herbicides onto the large surface area of the organic matter fraction.

The development of herbicides for beet on mineral soils preceded that for organic soils, but the other pre-requisite of drilling-to-a-stand, monogerm seed, has been a plant breeder's aim for two decades. It is only in the last three years that the yields of these varieties have reached 95 per cent of the yield of multigerm varieties, and at the same time careful selection has largely overcome their tendency to bolt after early or mid-season sowing.

In order to take early advantage of new developments, both husbandry farms began experiments to enable them to devise convenient, minimum-labour beet-growing systems before either fully effective herbicides or completely satisfactory monogerm seed were available.

In traditional sugar beet growing it has always been the aim to have final plant populations as near to 30,000 per acre as possible in order to maximise yields without having too many beet to slow down harvesting in the days of hand knocking and topping. With skilled handwork at singling this traditional population can usually be achieved. There are two alternative methods of eliminating hand singling; one is to drill-to-a-stand and the other is to use some form of mechanical thinning. With both methods there is less positive control of plant populations than with hand singling so that one of the first requirements is to define the population limits that can be tolerated. At Gleadthorpe between the years 1962–67 yields have been taken from plant populations varying between 14,000 and 42,000 per acre. Between 25,000 and 40,000 plants per acre yields have changed very little. With machine harvesting the number of roots to be lifted is no longer important as long as none is lost through the cleaning chains. In conditions when poor or variable germination is to be expected the aim should be a final stand of 35,000 plants per acre so that a reasonable population will be achieved even if the germination falls considerably.

Data collected between 1960 and 1968 at Gleadthorpe indicate that only 35 per cent field emergence may be expected on average and seed spacing must not be more than 4 inches if a reasonable population is to be established in most seasons.

Conditions for emergence and early growth are better on the warmer black soils of Arthur Rickwood E.H.F. In a test in 1966 80 per cent field emergence was obtained and during 1966–68 plant population studies showed that on 20-inch rows there was very little change in yield between 15,000 and 35,000 plants per acre. On this basis 6-inch spaced drilling has been used successfully and it is believed that even 8-inch spacing would be quite safe for medium to late sowings.

Despite intensive marketing and development, the use of mechanical thinners has never been popular. During the early 1960's at Gleadthorpe and later at Arthur Rickwood E.H.F. work was started to determine the yield penalty which may result from the use of thinners and to find out how much hand labour mechanical thinning actually saved. Yields at Gleadthorpe after full handwork were 17·0 tons per acre and the reduction after using a down-the-row thinner twice was only 0·9 tons per acre. The reduction in the amount of hand labour required was only 25 per cent because 'seconding' was also done. Probably the greatest advantage was in giving greater flexibility of timing of second stage handwork.

The use of down-the-row thinning is not favoured in the fens because rapid growth produces a tangled weft of weed and beet roots which can lead to a very ragged action from a mechanical thinner. However, the reciprocating action thinner used in tests at Arthur Rickwood E.H.F. did cut cleanly through the braird and a satisfactory plant distribution was obtained. The original seed spacing had an important effect. When seed was sown at 1½ inches a very thick braird resulted and full machine work left a final population of 38,000 plants per acre—somewhat higher than has proved to be necessary on black soils. After drilling seed at 3-inch spacing full machine work left an almost ideal 30,000 plants per acre but with some 'gappiness', and there was a yield loss of 2·7 tons of beet per acre compared with the 19·9 tons produced by full handwork.

It seems therefore that thinners *can* cope with both the stony and some-

times undulating conditions at Gleadthorpe and also, provided seedrates are suitably reduced, with the dense weft of the fens.

The other adjunct to drilling-to-a-stand is an effective herbicide programme. No special herbicides have been developed for sandy soils and tests at Gleadthorpe have been with commercially available materials; IPC/endothal, CIPC/IPC/fenuron mixtures and pyrazon. IPC/endothal used in 1961 gave about 50 per cent weed control and the two newer herbicides used in 1967 and 1968 were slightly less effective than that. This may have been due to the very wet May in those seasons. Although pyrazon can also be used as a post-emergence herbicide it was slightly less effective when used in that way. All herbicides tended to reduce yields.

As only partial weed control has been achieved by pre-emergence herbicide applications, inter-row cultivation has to be carried out. The policy at Gleadthorpe is to save money on chemicals by band spraying and to accept extra labour on inter-row cultivation. In favourable seasons beet drilled-to-a-stand may not need handwork but in most years application of a post-emergence chemical or labour for weeding will be necessary.

Pyrazon has also been tested pre- and post-emergence at Arthur Rickwood E.H.F. but it simply does not control weeds on organic soils. A mixture of IPC and medinoterb acetate has been compared with a CIPC/IPC/fenuron mixture during 1967 and 1968 at rates 25 per cent above and below those commercially recommended. These tests were done on 5 occasions in 1967 and on 3 occasions in 1968 under a wide range of soil moisture conditions since it is known that herbicides can be a good deal more active on wet organic soil than on dry. At equivalent dose rates the CIPC/IPC/fenuron mixture was rather more active than the IPC/medinoterb acetate mixture; this was partly due to its greater activity in relation to annual meadow grass. On a site of high organic matter content (ca. 35 per cent) the highest rate of the IPC/medinoterb acetate mixture only controlled 60–70 per cent of the weeds present.

Soil incorporation had no consistent effect on the activity of the two herbicides except for two sites, where the activity of the CIPC/IPC/fenuron mixture in controlling fat hen was materially increased by incorporation.

In the one instance when the CIPC/IPC/fenuron mixture was applied to very wet soil, the highest rate used eliminated practically all weeds, but since it was also applied near to beet emergence (18 days after drilling) it reduced beet vigour and populations considerably, and reduced yields by 2·7 tons per acre. On average, herbicides did reduce beet vigour at the singling stage, but had little effect on populations at singling (or at harvest). The yields on plots treated with herbicides were about 1 ton per acre less than the handworked controls.

In 1968 the tests were taken a stage further by including comparisons of the recently available post-emergence selective herbicide phenmedipham. Whereas 'normal' rates of CIPC/IPC/fenuron used alone left about 40 per cent of the weeds present on control plots, this residue was down to about 13 per cent when a post-emergence band spray of phenmedipham had been used. Indeed at one site where a pre-emergence contact herbicide had been used to clean up the weed growth which pre-emerged the beet, a combination of the normal 9 pints per acre rate of CIPC/IPC/fenuron mixture with 5 pints per sprayed acre of phenmedipham led to 94 per cent weed control.

An IPC/ fenuron and phenmedipham combination was equally effective here.

Yields from handworked plots in this series of experiments averaged 16·1 tons of clean beet per acre and plots drilled-to-a-stand and treated entirely with herbicide yielded 16·6 tons of clean beet per acre. In the wet year of 1968 weed control by herbicides was probably more effective than by hand so that the 'control' yields may have been less than normal because of weed competition. Nevertheless there is no evidence of disastrous yields following drilling-to-a-stand on peatland.

It seems reasonable then to prescribe a minimum labour beet-growing system for peatland of up to 35 per cent organic matter content. A 'stale seedbed' is prepared as early as possible (say late February); beet drilled at not less than 6-inch spacing during late March and early April and any early emerging seedling weeds killed by a contact herbicide just before beet emergence. At this time one of the two commercial soil acting mixtures is applied. A single properly timed post-emergence application of phenmedipham will then often suffice to kill those weeds emerging in late May and in most seasons even the usual June or July walk weeding may be unnecessary.

On sand land the establishment of a suitable plant population is more difficult and a seed spacing greater than 4 inches is unwise. In most seasons weed control by herbicides will need a pre- and post-emergence application and it is likely that band spraying and inter-row cultivation will be the most economic.

The cost of monogerm seed and band spraying pre- and post-emergence herbicide is around £10 per acre which compares favourably with the £15 or so for all-handwork systems.

GRASSLAND MANURING

D. O. Williams, *Great House Experimental Husbandry Farm*

Production from grassland can be maintained at a high level over many years using fertilizer nitrogen, without detriment to the soil, the stock or the persistency of the sward. It is, of course, essential that the soil be kept reasonably well drained and that any lime deficiency be corrected. The requirement of pastures for mineral fertilizers other than nitrogen can be quite low; this will depend on the available nutrients in the soil and on the return of nutrients in animal excreta. Grassland for conservation, however, may need substantial dressings for optimum growth.

Although these basic facts are now well established farmers have been slow to adopt more intensive fertilizer use. Herbage production and utilisation is a process of considerable complexity influenced by many factors. These have to be integrated into grazing and conservation programmes if an economic return is to be obtained on an intensive system. The merits of various intensive grazing systems, which have not been adequately compared experimentally, have to be considered. The practical implications of the seasonal variation in response to nitrogen, water relationships, and the interrelation of nitrogen level and duration of regrowth and their effect on yield and quality of herbage, must be understood. Nitrogen is a

major cost factor in intensive grassland systems and knowledge of the optimum level of use and the most economic source is needed.

Information derived from recent experiments on Experimental Husbandry Farms relevant to these problems follows, together with an introduction to a nationwide series of experiments on grassland manuring which has been proposed by a joint committee of Research workers and N.A.A.S. specialists, in an attempt to provide a comprehensive study of the effects of environment.

Mineral Fertilizers

The requirement of grassland for phosphate and potash fertilizers is influenced by several factors. The sward may be cut and the nutrients removed in the herbage, or it may be grazed and some of the nutrients returned to the sward in dung and urine. A high level of output obtained by the use of nitrogen fertilizer, for example, will increase the demand for phosphate and potash. A third factor is the capacity of the particular soil type to provide available phosphate and potash.

The effect of different levels of nitrogen, phosphate and potash on the herbage production of a cut ley was measured over a period of five years at Liscombe E.H.F. Annual dressings of 32 units P_2O_5 per acre were required to maintain grass production regardless of nitrogen level. If this plant nutrient was not applied yields fell. The need for potash was greater; 60 units K_2O per acre were applied annually to obtain optimum yields when 84 or 168 units N per acre were applied, and 120 units K_2O per acre were necessary to maintain the response to nitrogen when 252 units N per acre were applied.

The large potential requirement for potash was confirmed in a silage crop manuring trial at Liscombe in which three silage cuts were taken annually and the autumn aftermath grazed by sheep. In this trial, 60 units K_2O per acre were adequate for maximum yields in the first year, but 120 units K_2O per acre were needed in the second year and 180 units K_2O per acre were required in the fourth year for maximum yield when 240 units N per acre were applied. Where no potash was used, soil potash reserves were rapidly depleted and low yields were obtained with both 120 and 240 units N per acre.

It is wasteful to use more potash than is required for optimum yield of crops for conservation, for the excess will be taken up by the crop, thus increasing the potash content of the dry matter without a corresponding increase of yield. In intensively managed pastures excess potash can be both wasteful and induce an animal health problem. Luxury uptake of potash in spring herbage causes a reduction in magnesium content and may induce hypomagnesaemia in grazing animals. The risk can be minimized by applying potash in late summer when natural herbage magnesium levels are high. It was found at both Great House E.H.F. in the Pennines and at Liscombe E.H.F. in Somerset that potash applied in spring or autumn was equally effective in producing yield increases.

Response to Spring Nitrogen

Nitrogen provides the most valuable means of increasing herbage yields, and, although this is generally accepted by farmers, surveys of fertilizer

use show that on average only about 60 units N per acre are used on leys and 20 units N per acre on permanent grass.

A large proportion of the nitrogen used is applied in the spring. At this time the response to nitrogen is about twice that obtained later in the season because sufficient soil moisture is available for maximum plant growth. In a cool spring available nitrate in the soil allows plant growth to proceed before the soil temperature has reached the level necessary for mineralisation of soil nitrogen.

Applications of 32, 63 and 126 units N per acre in the spring gave good yield responses in the first silage cuts at Liscombe E.H.F., over a period of three years. The best yields at the second silage cut were obtained, however, from swards which had received no nitrogen in the spring. This was due in part to the contribution from clover and was most marked in the first and second years when the clover was vigorous. The yields at the third silage cut or third grazing were similar whatever rate of spring nitrogen had been used.

At High Mowthorpe E.H.F. nitrogen was applied in five dressings which provided either 50 per cent or 25 per cent of the nitrogen in the spring. There were no differences in total yield from two-year leys used in this comparision but the higher spring rate of nitrogen gave increased herbage yields in the spring and lower yields in the summer.

Seasonal Responses to Nitrogen

The effect on seasonal grass growth of a large single application of nitrogenous fertilizer in the spring compared with the same quantity applied at intervals during the growing season has been studied over three seasons at Rosemaund and Boxworth E.H.F.s. The bulk dressings of 160 units N per acre were applied in mid-March and the split dressings of 40 units N per acre were applied in mid-March and following each of the first three cuts.

An early cut was taken at the end of April each year at Rosemaund, followed by three further cuts at intervals of about six weeks. The total yield of dry matter from split dressings was 12 per cent more than from bulk dressings. From split applications the average percentage distribution of the total yield from the four cuts in sequence was 12 per cent, 56 per cent, 17 per cent and 15 per cent. The comparative distribution for the bulk application was 25 per cent, 61 per cent, 9 per cent and 5 per cent. The bulk application gave a high yield of spring growth and only poor yields at the last two cuts. The split dressings gave moderate yields at the first, third and fourth cuts but a large proportion of total yield from both treatments was produced in early summer and harvested at the second cut.

The two methods of using nitrogen were tested at Boxworth for two seasons on paddocks grazed by groups of young heifers. Grazings were timed to utilise grass growth at a grazing stage and so the dates of first grazing and interval between grazings were different each year and one third of the paddocks were conserved as hay to remove surplus summer grass. The single dressing promoted earlier and greater grass growth which then fell off rapidly. Greater dry matter production in mid-summer was obtained from split dressings which provided a more even seasonal production and greater total production of grass dry matter.

In contrast to dry matter yields, the liveweight gain of heifers on the single application treatment was greater than on the split application treatment. Liveweight gain was markedly seasonal, half of the annual gain being produced from the first grazings of the paddocks when the bulk treatment gave the greater yield of dry matter and consequently a greater liveweight gain. This initial advantage was maintained throughout the grazing season because the herbage at subsequent grazings was less efficiently utilised.

Nitrogen treatments had little effect on herbage digestibility but crude protein content was higher early in the season following the single application of nitrogen.

In 1968 at Boxworth, 300 units N per acre were applied in two dressings compared with the same quantity in six dressings, thus increasing the intensity compared with previous years. The paddocks were grazed seven times. As in the less intensive trial, the split fertilizer treatment gave greater yields of summer grass and slightly greater yields of dry matter and digestible organic matter over the season. Liveweight gains were slightly higher on the bulk fertilizer treatment, with substantially higher gains in April and May, but these were followed by poor performance on both treatments later in the season.

High Rates of Nitrogen

High nitrogen rates have been investigated on leys and permanent grass at Great House E.H.F. The limit of response was reached on both types of sward at 600 units N per acre, under a system of cutting five times a year. Nitrogen was applied in four equal dressings, before the first four cuts, at annual rates of 200, 400, 600 and 800 units N per acre. Phosphate was applied at 100, 150, 200 and 250 units P_2O_5 per acre per annum with potash at 200, 300, 400 and 500 units K_2O per acre per annum respectively, so that the responses to nitrogen at high rates would not be limited by a shortage of these nutrients.

The first cut each year was in mid-May followed by second and third cuts at intervals of about four weeks, a fourth cut five weeks later and a fifth cut six or seven weeks later in early October. Under this cutting regime plots not receiving nitrogen were harvested at an early grazing stage and the other treatments were at a late grazing or silage stage depending on the level of nitrogen applied.

Yields have been maintained over a period of six years, and in fact in the sixth harvest year yields have been higher than in previous years at all levels of nitrogen application. The ley without nitrogen has yielded about 45 cwt of herbage dry matter, whereas the permanent sward without nitrogen has yielded 30 cwt of dry matter each year. This difference was due to the ley's greater clover content, which contributed to production directly as clover foliage and indirectly through the stimulation of the companion grasses by the transfer of nitrogen fixed from the atmosphere.

At 200 units N per acre the yield of herbage from both swards has been equal to about 75 cwt herbage dry matter per acre, and with 400 units N yields have been about 100 cwt of dry matter from both swards. Six hundred units N per acre resulted in a further yield increase of only 8 cwt dry matter per acre and for the highest rate of nitrogen only a negligible extra yield

increase was obtained. This experiment indicates that in terms of dry matter production it was not economic to apply more than 400 units N per acre to either sward.

Nitrogen was applied in the form of ammonium nitrate-lime, but despite the neutralising value of this material low soil pH developed on the high nitrogen treatments. This was rectified by applications of granulated ground limestone in 1967. Soil analyses show that, although soil magnesium reserves have decreased, herbage chemical composition and yield have not been affected. No other deficiencies have been identified. Herbage from the 600 and 800 units N per acre swards contained high levels of nitrate-N, particularly in mid-summer.

Changes in the botanical composition of the swards have occurred. Perennial ryegrass has become dominant in the permanent swards which receive nitrogen. In the ley, clover has only persisted in plots receiving no nitrogen and in these it has continued to make a useful contribution to yield. Perennial ryegrass has become dominant on the ley swards also. Docks were a serious weed on the ley and were controlled by 2,4-D application in 1967 and 1968.

The original permanent sward contained about 60 million tillers per acre. This density has been maintained with applications of up to 400 units N per acre but the two highest rates of nitrogen have developed into more open swards with tiller densities of about 30 million per acre. On leys with a density of 30 million tillers per acre in the second year after establishment densities have increased at all rates of nitrogen to about 40 million tillers per acre.

Source of Nitrogen

It has been claimed that anhydrous ammonia is more persistent than solid fertilizers and can replace periodic top dressings on grassland. It would be very convenient if a single operation in the spring provided a pasture with a gradually released supply of nitrogen throughout the growing season.

In several experiments yield responses were lower with injected anhydrous ammonia than with equivalent rates of ammonium nitrate. At High Mowthorpe E.H.F. anhydrous ammonia gave yield responses 15 to 25 per cent lower when used at rates of 240 and 360 units N per acre. Ammonium nitrate also gave better yield responses at Boxworth E.H.F. where the fertilizers were applied as single dressings of 190 and 280 units N per acre in March.

Soil type and climate are probably responsible for variation in yield response. On peaty loam soil at over 1,000 ft in the Lancashire Pennines anhydrous ammonia was 30 per cent less effective than ammonium nitrate when applied at 200 units N per acre in March. However, at Trawscoed E.H.F., Cardiganshire, single dressings of both fertilizers at rates of 140 and 250 units N per acre were equally effective.

The results at Boxworth, High Mowthorpe and Great House show that ammonium nitrate is more persistent than anhydrous ammonia, yields at later cuts being consistently higher. It was also noted at all centres that response to anhydrous ammonia at the commencement of spring growth was poor and that ammonium nitrate always gave very much better yields at the first cut.

Split dressings applied in March and June at High Mowthorpe gave higher yields for both fertilizers than single large dressings in March. Injection of anhydrous ammonia in June was difficult because of the dry, hard state of the soil. At Boxworth, July injection proved impossible to carry out for the same reason. Split dressings gave only slight increases in yield at Great House. On all swards ammonium nitrate applied in periodic dressings before each cut only slightly improved seasonal production and did not increase total production over that from March and June dressings.

These experiments show a lower efficiency for anhydrous ammonia but this may be offset by lower unit costs. Further experiments may show that liquid and solid nitrogen fertilizers can be complementary in a grassland manuring programme, but at present broadcast application of solid fertilizer to sustain pasture yields through the season remains the most satisfactory method of supplying nitrogen. In the future, slow release and coated fertilizers which are now being developed in U.S.A. may provide a more suitable single application source of nitrogen.

Frequency of Defoliation

Strip or paddock grazing are techniques for increasing the production and utilisation of pastures compared with set stocking. The duration of the growth period between defoliations is an important factor in the management of grazing systems and its effect was studied at Liscombe E.H.F.

In the absence of nitrogen the annual yields from swards with 30-day regrowth periods were twice those from swards with 10-day regrowth periods. This effect was reduced when nitrogen was applied. When 252 units N per acre were applied in split dressings, swards allowed 30 days regrowth yielded 50 per cent more than swards allowed 10 days regrowth. This advantage was reduced to 30 per cent if 504 units N were applied. The average yield increase obtained by lengthening the growth period from 10 to 20 days was 30 per cent, and from 20 to 30 days a further 30 per cent.

Swards receiving 63 units N per acre with 30-day regrowth periods yielded as much herbage as swards with 20-day regrowth periods receiving 126 units N per acre, and as much herbage as swards with 10-day regrowth periods receiving 252 units N per acre.

There is an upper limit to the amount of herbage which can be efficiently grazed (or handled by silage or hay-making machinery); the level of yield required is reached more quickly at high rates of nitrogen fertilizer application than at low rates, and because this means more frequent defoliations responses can be disappointing. The rate of nitrogen applied to grass should be related to the growth period expected to elapse before defoliation, in order to obtain the required yield with minimum nitrogen usage.

Intensive Grazing by Dairy Cows

Responses to nitrogen on grazed pastures have not always been as large as those suggested by cutting trials. In a trial at Great House in 1967 paddocks receiving 400 units N per acre produced more dry matter and more cow grazing days per acre than paddocks receiving 200 units N per acre when stocked over the season at 0·3 or 0·5 acres per cow (400 N) and 0·5 or 0·7 acres per cow (200 N). In this trial response to nitrogen at

the 200 N rate was good in terms of dry matter yield estimated before grazing but the additional yield at the 400 N rate was about half that indicated by cutting experiments.

In a trial in 1968 differences in herbage yields of paddocks receiving 160, 240 and 360 units N per acre and grazed by dairy cows at 21 to 28 day intervals were again smaller than expected. Paddocks were badly poached at the first grazing and over the season more than half of the herbage available at each grazing was not eaten.

In these trials dairy cows were not continuously kept on a paddock grazing system and it is probable that better utilisation would be obtained if stock were fully conditioned to paddock grazing. The poor apparent response to the highest levels of nitrogen may have been due to the influence of several factors, including the limitation of response by frequent defoliations and the effectively higher nitrogen status of the grazed sward due to recirculation of this nutrient through the grazing animal.

Future Experiments on Grassland Manuring

Climate and soil type affect the response to nitrogen and the Joint Research/N.A.A.S. Committee on Grassland Manuring have proposed a nationally co-ordinated series of experiments to provide a comprehensive study of factors involved in grassland manuring over a wide range of conditions. It is intended that there should be at least 24 sites for first stage experiments in which similar treatments will be applied to pure grass swards over a wide range of conditions. The first of these experiments will investigate nitrogen manuring of grass cut at grazing frequency to determine the most suitable patterns of seasonal application to adopt and the optimum annual nitrogen rates. A second type of experiment will investigate nitrogen manuring of grass cut for conservation. The cutting frequency proposed is designed to produce high-quality forage.

The second stage experiments will be designed to obtain more information on the influence of the grazing animal on the response of grass to nitrogen. The relationship between the response under grazing and cutting will also be investigated in an attempt to determine 'correction factors' by which the results of cutting trials may be better related to the grazing situation. These experiments will be sited over a wide climatic range and on contrasting soil types. The number of centres will be fewer than for stage one experiments because of the difficulties and the cost of carrying out experiments with livestock.

The information derived from these co-ordinated studies will, it is hoped, provide advisers and farmers with the detailed technical knowledge that will enable them to devise practical management systems to exploit the full benefits of grassland manuring.

INTENSIVE SHEEP PRODUCTION ON PERMANENT GRASS

F. J. Round, *Rosemaund Experimental Husbandry Farm*

Experimental work on the intensification of sheep on permanent grassland and leys is currently in progress at Bridget's, Drayton, Great House, Liscombe, Rosemaund and Trawscoed. Many aspects of sheep production are being investigated; winter management, housing, grazing and summer paddock grazing, stocking rates, nitrogen usage, and fat lamb production together with disease and veterinary aspects. It is not possible in this article to give a detailed account of all aspects of this work but simply to review some of the current trends and developments.

At Drayton and Rosemaund the intensification of sheep on an all grass farm is being investigated using a statistically designed and fully randomised experiment. On other farms a great deal of valuable experimental work on the intensification of sheep has been carried out on farm units or 'farmlets', each unit being looked upon as a self-contained farm which usually investigates one main treatment effect (e.g., increase in stocking rate or use of nitrogen).

At Bridget's a farm unit was developed to study fat lamb production from an all grass downland farm. The Clun ewes put to a Dorset Down ram were managed at approximately 3·3, 4·3 and 5·4 ewes per acre at 50, 150 and 250 units of nitrogen respectively. Stocking rates were adjusted from season to season in the light of experience. Grazing was mainly on S.23 ryegrass with a separate conservation area of timothy/meadow fescue. This experiment, like most farm units, was designed to produce financial information on the profitability of sheep in addition to the physical data. At Liscombe two 20½-acre units were set up in 1962 to investigate the many problems of intensification on Exmoor. A comparision was made between Welsh Half-breds stocked at 3½ ewes per acre and the smaller, less prolific Welsh Mountain ewe stocked at 5 per acre. As knowledge was gained of the management of these all grass units for the production of fat and store lambs so the stocking rates were gradually raised to 5 and 7½ ewes per acre. Great House, on the Pennines, has a 40-acre unit set up on permanent pasture and leys to look at the problems which intensification bring both in management techniques and disease control. Gritstone, Teeswater x Gritstone and Masham ewes are all crossed with a Suffolk ram. The stocking rate has gradually increased each year up to the present total of 260 ewes, i.e., 6½ ewes per acre. At Trawscoed Welsh Half-breds are stocked at 7½ and 9 ewes per acre on grassland receiving 300 units of nitrogen. These sheep units form part of a mixed stocking experiment.

Wintering Ewes

One of the main factors which limits the intensification of sheep enterprises, particularly on heavy land is the difficulty of carrying high stocking rates at grass during the winter months. Inevitably there are problems of poaching, retarded growth of grass in the following season, and possibly less grass

produced in the initial spring period just after lambing when the pressure on grassland is very great.

One solution to the problem of wintering sheep is to house them. Experiments at Drayton, Great House and Rosemaund have shown that in-wintering is a convenient system and provides the shepherd with easier working conditions. Results indicated that ewes can be housed at a density of one ewe per 10 sq. ft without the apparent need to provide more exercise than the ewe gets within the pen. Both slatted floors and dry straw litter have proved equally satisfactory. Ewes under housed conditions do not appear more prone to foot-rot although considerable care was taken to treat cases of foot-rot before housing. Respiratory diseases and a tendency to shed wool have not been problems, but at all centres adequate ventilation has been available. The ewes at both Drayton and Rosemaund were housed abruptly whereas those at Great House were housed only at night for several days to acclimatize them to winter conditions. Both methods of housing gave satisfactory results. Feeding was based on good quality hay fed *ad libitum*. Consumption varied from 3 lb per head with the Rosemaund Welsh half-breds to about 4 lb with the Scotch half-breds at Drayton. This is possibly little more than would be fed to outwintered sheep kept at high stocking rates. At all centres a steaming-up ration was fed in the last 4–6 weeks of pregnancy, increasing from $\frac{1}{4}$ to 1 lb or $1\frac{1}{2}$ lb per ewe per day.

Results indicate that housing under lowland conditions does not reduce lamb losses, most of which occur in the first 10 days. Although lambs born to indoor ewes have on average been $\frac{1}{2}$ lb lighter, their subsequent performance at grass has been similar to those born out of doors. The lambing percentage of housed ewes has been slightly higher at both Drayton and Great House but such a difference has not been recorded at Rosemaund.

Winter Grazing

At Drayton and Rosemaund the effects of winter grazing and treading on heavy land have been investigated on leys and permanent pasture. The stocking rates ranged from 2 to 4 ewes per acre grazed during the months December to February. There was a clear visual difference between the grazed and rested plots at Drayton in each spring. The winter rested plots always looked greener in early spring but in 3 out of 4 years there were no differences in yield by the middle of May. At Rosemaund not only did the rested plots appear greener but in three seasons out of four there was a 15 per cent increase in productivity during the subsequent grazing season.

An alternative to winter grazing all available grass is to stock a small area of land at very high stocking rates and rest the remainder. This technique was used on the sheep units at Bridget's where the 'sacrifice' paddocks formed part of the summer conservation area. Liscombe also winter stock at 30–50 ewes per acre on 'sacrifice' paddocks in conjunction with an 'easy feed' silage system. Even on light soils areas around feed racks become muddy and considerable foot problems can result. It has also been noted that these wintered pastures become markedly more weedy although they have maintained their productivity. Under these highly intensive winter stocking systems grazing is almost impossible and the ewe is entirely dependent upon supplementary feeding to maintain her on an adequate plane of nutrition, particularly during the last six weeks of pregnancy.

Summer Management

As ewes lamb they are taken from the main housing pens and placed into small individual pens with their lambs for the next 24 hours or even longer. This minimises mismothering, a problem observed in many housed flocks, and also enables the lambs to suckle the ewe and gain strength before facing the rigours of an outdoor life. To gain the maximum benefit from housing and winter resting of the pastures, lambing should be timed to coincide with grass growth in the spring. For this reason the lambing season on all farms (with the exception of Trawscoed who lamb in February), commences in March. The units are therefore not at full stocking pressure until early April when in a normal season grass growth may be expected to keep pace with the need of the ewes under lowland conditions. At Liscombe and Great House, however, April is often a critical month with grass being scarce and not always adequate for the needs of the ewes.

At all centres the sheep are managed on a paddock grazing system. Most farms have 6 paddocks for each flock but the number of paddocks varies from 5 at Drayton to a maximum of 8 at Great House. Bridget's is the only centre where there was provision for the lambs to forward creep.

Conservation is used as a tool of grassland management to remove grass surplus to the sheep's requirements or grass which has grown too strong to provide a highly digestible food for the lambs.

Stocking Rate and Nitrogen

A large nitrogen and stocking rate for sheep experiment at Drayton and Rosemaund has been designed to compare three nitrogen levels (namely 0: 120: 240 units) each carrying three overlapping stocking rates according to the following pattern:

Nitrogen units/ac	Stocking rate (ewe/ac)				
Drayton:					
0	2·4	3·0	3·6	—	—
120	—	3·0	3·6	4·2	—
240	—	—	3·6	4·2	4·8
Rosemaund:					
0	2·8	3·5	4·2	—	—
120	—	3·5	4·2	4·9	—
240	—	—	4·2	4·9	5·6

Each of the nine treatments consists of a self-contained flock of 24 ewes managed for fat lamb production on a paddock grazing system. The grazing needs of the lambs take priority over conservation, but surplus grass is conserved as silage or hay in order to provide ewes with winter keep during the housed period. With the exception of the no nitrogen treatments at Drayton which have not been able to conserve any grass, all other treatments have been self-sufficient.

The ewes are brought off their plots on an individual treatment basis

and housed as soon as the autumn grass will no longer support them. Lambing commences in early March and the ewes and lambs are turned out to grass within 2 days of lambing.

Lambs are sold as they become fat at approximately 75 lb live weight.

Results to date show that at each level of nitrogen used, an increase in stocking rate has also increased the total production of lamb per acre, without apparently increasing the proportion of store lambs. In 1967 it was possible to sell over 90 per cent of lambs fat from all treatments at Rosemaund. An increase in nitrogen at a given stocking rate has not normally resulted in an increased yield of meat per acre but has resulted in a substantial increase in the quantity of grass available for conservation.

Rosemaund (2-year average)

Nitrogen	Stocking Rate	Total lamb per acre (lb)	% Stores	D.M. Conserved (cwt)
0	2·8	292	15	139
	3·5	404	11	85
	4·2	431	6	66
120	3·5	325	31	165
	4·2	461	33	121
	4·9	506	21	96
240	4·2	439	36	163
	4·9	527	21	124
	5·6	544	34	101

Because of the large surplus of grass, stocking rates at Rosemaund were increased in 1968 to give a range from 3·6 to 7·2 ewes per acre at nitrogen levels adjusted to 0:90:180 units per acre.

Work at Liscombe confirms that individual performance of lambs has not decreased as stocking rates have increased but saleable hay made from surplus grass has decreased with each increase in stocking rate. Even at 9 ewes per acre at Trawscoed 80 per cent of lambs have gone fat by the middle of August

Disease control on an intensive sheep system is of the utmost importance. Very careful monitoring of the flock is necessary in an attempt to keep the sheep healthy and at their peak performance. Modern anthelmintics are now very efficient and can be used as necessary to keep worm problems in check. Coccidiosis, however, is not so easy to treat and appears to be a problem on many of the units. It has been particularly severe at Great House and Bridget's where at present a considerable amount of investigational work is in progress. Metabolic disorders are another problem affecting most of the units. Because losses from hypomagnesaemia have been quite serious, calcined magnesite has been fed to the ewes during April at Liscombe and Rosemaund. Bridget's and Drayton have also recorded difficulties with this disorder. Cobalt has been a problem on the Old Red Sandstone Soils at Rosemaund but the routine spraying of cobalt sulphate

on the paddocks has prevented loss of liveweight gain due to cobalt deficiency in the last two seasons.

Discussion

Experiments on the intensification of sheep have shown that by increasing the stocking rate with the aid of additional nitrogen an increase in lamb production can be expected without necessarily leaving a higher proportion of store lambs at the end of the grazing season. However, higher outputs of lamb do not necessarily mean more profit. A considerable part of the benefits of increased production can be absorbed by rising variable costs. At stocking rates of 5·4, 6·3 and 7·2 ewes at 0·90 and 180 units of nitrogen per acre at Rosemaund the production of lamb has been 656, 717 and 769 lb per acre but the gross margins have remained static at about £41 per acre. At Liscombe the Welsh half-bred lambing at 140 per cent and stocked at 5 ewes per acre has produced a similar gross margin of £20 acre to that obtained from the smaller full mouth draft Welsh Mountain ewe lambing at 100 per cent and stocked at 7½ ewes per acre. The size of ewe and lambing percentage have both been important factors in the final profitability of the sheep enterprise at Liscombe. Under the downland conditions at Bridget's the gross margins for the low, medium and high units were rather disappointing at £12, £15 and £20 respectively.

Maintaining high 'all the year round' stocking rates creates many difficulties. Winter poaching and treading particularly on heavy land can be overcome by housing. The March and April period is normally an anxious time as the demand by ewes and lambs can, under adverse weather conditions, exceed the grass growth. As grass growth declines in mid-season, grazing pressure must be relieved by selling off fat lambs. The use of a Dorset Down ram on Cluns and Welsh Half-breds has produced a compact lamb readily gradable at 70–75 lb live weight under intensive grazing conditions.

Work on the Experimental Husbandry Farms indicates that the intensification of sheep on an all grass farm is technically possible. Where this intensification is obtained from higher lambing percentages reared and increased stocking rates without a large increase in nitrogen usage, then an intensive sheep unit may be considered as a viable commercial proposition.

STRAWBERRY PRODUCTION:

SURVEY OF RECENT EXPERIMENTS

Hilary M. Hughes,* *Efford Experimental Horticulture Station*

Of all the fruit crops the strawberry gives the quickest return on capital invested. Thus, experiments with strawberries, both on the Experimental Horticulture Stations and those done in co-operation with the Regional and County Advisers on growers' holdings, have given useful results without the long time-lag normal with other fruit crops.

*Now at N.A.A.S. Wolverhampton.

Variety testing of strawberries is obviously an important and continuous process. New varieties, raised at the Research Institutes and those from private sources and from overseas, are first tested at the National Fruit Trials in Kent and those showing promise are immediately further tested at Kirton E.H.S.—representative of the important East Anglian silt soils—and at Efford and Ellbridge E.H.S. for annual cropping and under protection at Luddington. Varieties continuing to show promise are further tested at the other E.H. Stations, covering a wide range of soil types and local conditions. One of the surprising results of this wide testing has been that, using healthy virus-tested stocks, it has been noted that strawberries will crop well in most localities given reasonable soil and careful cultivation. Varieties, too, generally behaved in the same way at all the centres, although occasionally there were local differences. The yield is lighter in the north where the growing season is shorter. Even so, it is interesting to note the satisfactory crops obtained at Fairfield in Lancashire and Cawood in Yorkshire and this suggests that if pickers are obtainable, strawberries can be expanded elsewhere than in the traditional areas.

New strawberry varieties can be registered under the Plant Variety Rights Act but rights are granted for distinctness only and not on merit. The distinctness tests are carried out at the National Fruit Trials and it sometimes happens that merit trials may run concurrently, and then the commercial characters of the new varieties are assessed at the same time as distinctness. This applies in particular to new seedlings raised at Research Institutes. The Experimental Horticulture Stations can provide additional information for the National Fruit Trials by growing this new material to determine how it behaves under their conditions.

The variety trials in the early 1950s showed that the newer Cambridge varieties far out-yielded the older standard varieties like Royal Sovereign, and in subsequent years all new varieties are now tested against Cambridge Prizewinner (early) and Cambridge Favourite (main crop). Redgauntlet was shown to be a valuable, large berried, heavy cropping variety and, within the last few years, Gorella aroused interest because of earliness and size of berries. But the trials conclusively showed that Senga Sengana, widely grown on the Continent, did not yield well under English conditions.

In these variety trials plants are usually grown as spaced plants, but many growers allow a matted row to form and there have been queries as to whether the results are the same. A useful trial at Terrington E.H.F. showed some crop increase, particularly of large fruits, with some varieties where matted rows were compared with spaced plants; the differences were not large. At Efford, Ellbridge and Luddington several experiments have been done comparing various spaced plant populations at different densities. At Efford and Ellbridge with one-year plants, increasing the density increased the crop. At Efford plants were thinned and retained for the second year, and provided the remaining plants grew to cover the in-row spacing, crop was not reduced, but neither was there any benefit from thinning. In none of these trials did increased density increase fruit losses from grey mould, but this may be because careful spraying is practised at the Experimental Stations.

Spraying Trials

Spraying against grey mould fungal infections has been tested in several trials at Luddington and in the Regions and yield increases of 60 to 80 per cent recorded. This work has clearly shown that season has the biggest influence on the incidence of this disease and also the importance of adequate spraying to achieve good wetting of all the plant surfaces, particularly flowers and developing fruit. Testing for taint, particularly on fruit destined for canning or processing, is primarily a responsibility of the firms producing the materials, but the Experimental Stations can supplement samples produced elsewhere by supplying fruit treated in known ways for residue testing. It is always extremely difficult to obtain strawberry yield data under commercial conditions, because of the difficulties involved in weighing frequent picks, so that the critical yield data obtainable on Experimental Stations can form a useful supplement to that obtained in commerce when pesticides are being tested.

Because of the dangers of introducing pests and diseases on the Experimental Stations, many of the control details are studied by Regional specialists on growers' holdings. A good example is red core, a serious, soil-borne fungal disease, unfortunately only too prevalent in some strawberry growing areas. Ellbridge has a general infection so variety trials there give some information on field resistance. The Regional pathologists are currently trying chemicals for drenching and root dipping against this disease and also comparing the value of ridging to help root growth.

Although red core is a problem in the west, south and south-east areas, verticillium wilt is more important in East Anglia and the Midlands. The severity of this soil disease is very dependent on season, damage being less noticeable in years without summer water stress. Choice of preceding crop and a wide rotation combined with healthy planting material are still the best solutions. Soil injection of D-D to give excellent control of the eelworm vectors of the serious virus disease called arabis mosaic has been dramatically demonstrated by N.A.A.S. trials in the south-west where this particular problem is most acute.

Nutrition Problems

The nutrition of the strawberry was fully investigated in an experiment at several of the E.H. Stations, when it was shown that, on fresh land and using healthy runners of commercial varieties, the strawberry had a low requirement for nitrogen. Further experiments at Efford showed no value from artificial soil conditioners, but a useful response to FYM even in the third year after planting. Strawberries grown at the Experimental Stations supplemented the detailed research work done at Long Ashton and provided material to determine levels of leaf ash analyses at which added fertilizer could be expected to give crop response.

A series of irrigation experiments on the free rooting silt soils at Efford only showed an economic response, both in crop yield and berry size, in really dry years, but at Luddington on a coarse sandy soil more liable to water stress, irrigation treatments, within experiments on controlling grey mould, gave worthwhile crop increases with no increase of rotted fruit where spraying was adequate.

Cold Stored Runners

The use and limitations of cold stored runners have been fully tested in trials in many counties, at several E.H. Stations and in demonstrations at the Royal Show in Warwickshire. The early trials compared fresh dug and cold stored runners and showed satisfactory crops could be obtained from all commercial varieties, provided the planting date of the cold stored runners was in June or July. Experiments now just being completed are testing a range of planting dates in Yorkshire, Hampshire and Cornwall to find the safe, latest planting date and are showing the need for earlier planting in areas where growth is slower in the late summer and autumn. The industry has been quick to realise the value of cold stored runners and several established runner raisers are now successfully storing considerable quantities of runners each year.

The use of May–June planted, cold stored runners to obtain late summer crops in August was checked, but yields of one to two ounces per plant were not economic. So-called perpetual varieties, mainly of Continental and American origin, and new seedlings showing perpetual flowering have also been fruited but with disappointing results. Breeders are aware of the need for extending the limited strawberry season and late varieties of promise may yet be found. There is still a need for a late variety to ripen after the main picking period in July and a limited demand for a reliable perpetual variety.

Herbicides

Within the last ten years a dramatic change in the cultivation of strawberries has occurred, as more and more growers turned to herbicides to control weeds and reduce labour costs. The N.A.A.S. have done numerous experments, both in the counties and at Stations, to test the herbicides available, and this has enabled herbicides to be evaluated on a wide range of soil types and under different conditions. Several experiments have demonstrated systems of non-cultivation are as good as cultivation. The materials in use at present, chloroxuron, lenacil and simazine, properly used can provide complete weed control in a non-cultivation system for most growers and advice on safe rates for specific soils is available from local Horticultural Advisers. However, problems of herbicide-resistant weeds are not yet solved and may be troublesome locally.

Similarly, the problem of runner control, particularly where non-cultivation is used, is not yet solved. Research work has shown no promise yet with chemicals that could be used to suppress runner initiation, or growth. Desiccant herbicides through guarded sprayers are frequently used and will clear alleyways, but they are rather expensive and do not solve the problem of runners rooting around the parent plant, or too thickly in the matted row.

An interesting series of experiments in progress at Efford, Kirton and Stockbridge House E.H. Stations is critically examining the effects of mowing off the plants after picking. Although not yet finished it has already clearly been shown that late mowing at the end of August reduced the growth and crop of Redguantlet and Favourite by at least 20 per cent so that if mowing is to be done it should be done promptly. In these experiments

the benefit of mowing has not been as favourable as was shown in experiments in Scotland, and the operation may become one of hygiene rather than increasing flower trusses.

Early Fruit Production

Efford and Ellbridge have carried out many experiments on the production of early strawberries under glass cloches and more recently under continuous tunnels made from polythene film. Variety testing indicated that heavy cropping and large fruited varieties were best; early varieties were associated with lighter yields, and earliness did not compensate for reduced weight. Planting date was important for total crop per plant, but crop per cloche could be maintained by closer spacing if planting was delayed. In a series of experiments it was found that the time of covering the crop was not critical if done before early March in the early areas, but later covering reduced the amount of early fruit.

With the increasing use of polythene tunnels the problem of mis-shapen fruit has frequently been raised by the industry. Evaluation of data suggests that although some varieties, particularly Favourite and Redgauntlet, are more prone to this trouble than Vigour or Prizewinner, seasonal conditions are most important and may involve factors over which the grower has little control. Plant breeders are aware of the need to ensure that varieties introduced are not shy in producing pollen, nor of a type, like Redgauntlet, in which many early flowers have few stamens.

In view of the tremendous use of black polythene as a soil mulch in many overseas areas, it is interesting how unpopular this is in England. Some experiments many years ago showed little real value for this process in England, since the lower soil temperatures in the spring and water retention under polythene mulch may be opposite to the requirements of the English grower, and herbicides solve our weed problem.

Harvesting Methods

Wherever strawberries are grown, the world over, the main problem is that of pickers. Given reasonably good and well drained soil, choice of right variety and adequate supply of virus-tested runners which are obtainable through the Ministry's certification scheme, and planted at a sensible time, a strawberry crop can be readily grown and kept clean with appropriate herbicides and pesticides. Yield will depend greatly on variety, exposure factors, soil, age of plant and density, and efficiency in protective sprays against grey mould, but should be at least three tons per acre. Yields of nine tons are uncommon but have been obtained; yields of five to six tons are frequent.

The problem is whether these crops are pickable. Organization of pickers is now the main problem for strawberry producers and one where the experimental programme cannot help much. Some useful work study has been done by advisers in Kent on the design of tray carriers which showed that row lengths of over 70 yards are uneconomic. The use of individual picking trolleys is being tested on a very limited scale. Any experimental results that enable growers to produce fewer, larger fruits will cheapen picking costs and may be preferable to increasing total yields.

Mechanical harvesting of strawberries would appear an impossibility for this delectable, but perishable, product. This is probably so for fruit for the dessert market, but for processing, particularly jam and juice manufacture, perhaps even for canning and freezing, mechanical harvesting may be possible. Preliminary work has shown that the Universal Vegetable Harvester developed by the N.I.A.E. could sever the whole plant, side fingers safely lifting most of the fruit, and leaves and stalks could be eliminated. Present varieties ripen over too long a season for this operation, but a short season variety could provide most berries ripe at once, leaving over-ripe and green fruit to be picked off by hand from a belt.

Although in a very early stage, results are promising enough for work to continue and the machine is to test harvest several varieties during 1969. Meanwhile, research is proceeding on the possible ripening of green berries, and plant breeders are seeking upright, quick ripening, high yielding varieties.

Many problems have been solved but new harvesting techniques could bring fresh growing problems. The efficiency of the strawberry industry, except for picking, is generally high and given new techniques not only should it be possible to extend the marketing period of this popular fruit, but export to Europe, after their main season is over, might be a possibility.

CONTAINER-GROWN SHRUBS

A. R. Carter, *Luddington Experimental Horticulture Station*

The demand for container-grown plants is increasing as garden centres become more widespread. Concurrent with this is an increase in requests for information on suitable composts and feeding programmes. To provide some basic information, experiments with one species, *Viburnum tinus*, were started in 1967 and extended to include several others in 1968.

Virburnum tinus: Rosewarne and Luddington E.H.Ss.

Composts	*Feeds*
J.I.P. 2	N 1 nitrogen 100 p.p.m.
U.C. mix C 50:50 peat:sand	N 2 nitrogen 200 p.p.m.
U.C. mix D 75:25 peat:sand	N 3 nitrogen 400 p.p.m.
In 1968, trace element Frit 235 A was added at ½ oz/bushel of the U.C. mixes.	The level of potash was constant at at 315 p.p.m.

The plants were fed at weekly intervals allowing 1/6th pint to each pot. All stock solutions were diluted 1:100.

Stock solutions: (quantities in 5 gal water)

	potassium nitrate	ammonium nitrate
N 1	3·5 lb	—
N 2	3·5 lb	1·5 lb
N 3	3·5 lb	4·25 lb

Watering systems

At Rosewarne, an open-air capillary bed on level ground, water level maintained by ball valve.

At Luddington, sand bed on ground, the sand kept moist by watering through a rose on the end of a hose-pipe.

Propagation

Viburnum tinus cuttings from a clonal stock were rooted under mist in early winter and were later potted into black polythene 'sleeve' pots which opened up to the size of a 4½-in. rigid pot.

Results

At Rosewarne, in the first year of the experiment (1967) J.I.P. 2 compost gave the best results and plant growth increased as the feed rate increased; the lowest rate of N applied to this compost gave better results than either of the U.C. mixes. U.C. mix D was slightly better than U.C. mix C. In 1968, J.I.P. 2 was again the best, but there was an improvement in the performance of the two loamless composts although U.C. mix D still had the edge on U.C. mix C.

In the first year at Luddington there was little difference in the results produced by any compost. The loam used in the J.I.P. 2 had a very high initial soluble salt concentration and this could have had an adverse effect on the growth rate early in the season. The nutrients provided by the N 2 rate seemed adequate. In 1968, there were no big differences between the composts although the plants in J.I.P. 2 produced on average more shoots than either of the others. U.C. mix C appeared to be slightly better than U.C. mix D. It was found that as the feeding rates increased, the number of shoots produced by all composts increased and in the two U.C. mixes, the spread and weight of plants also increased.

It appears from these results that the feeding rates could be increased, and it is likely that the full potential of the composts has not yet been achieved. J.I.P. 2 has produced good results at both centres, and the somewhat different behaviour of the loamless composts could be due to the watering systems in use. Some plants died during the experiment; at Rosewarne there were most fatalities in J.I.P. 2 but at Luddington there was no difference in this respect between this compost and U.C. mix D. There were fewest deaths in U.C. mix C.

At Luddington some plants in each compost were left to overwinter on the sand beds without further feeding. By early May the plants in J.I.P. 2 were superior in terms of colour and amount of new growth.

Escallonia 'Donard Seedling': Rosewarne E.H.S.

Cuttings were inserted under mist in December, 1967 and potted into polythene sleeves in February 1968 before being placed in a Dutch-light house. Growth was rapid and some bloom was produced. The flowers in the loamless compost were more pink than those in J.I.P. 2. In early May the plants were placed on the outside capillary benches and fed as for the Viburnums.

By mid-July some plants in the best treatments were of saleable size,

but because they were kept longer, they deteriorated. At the lower feed levels, plants began to show lack of nitrogen at an early stage.

As the feed rate increased, so did plant growth and weight in all composts. J.I.P. 2 again gave the best results.

Hebe angustifolia: Cornus alba siberica variegata: Efford E.H.S.

Plants of these shrubs, one evergreen and one deciduous, were grown in three loamless composts.

Composts

U.C. mix C 50:50 peat:sand
U.C. mix D 75:25 peat:sand
G.C.R.I. 75:25 peat:sand

Liquid feeds similar to those in use at the other two Stations were given at weekly intervals from 24 May until 24 October.

Propagation

Cuttings were inserted in a mist bench on 22 September, 1967 and overwintered in an unheated glasshouse. On 23 March, 1968, the rooted cuttings were potted into 500-gauge polythene sleeves and kept in the glasshouse until 18 April when they were placed outside on sub-irrigated ground benches.

Results

H. angustifolia

By the end of May, plants grown in the G.C.R.I. compost were darker green than those in the other two composts. Growth improved as the rate of feed increased and ultimately, plants receiving the lowest rate of N showed signs of nitrogen deficiency. The best plants were produced in the G.C.R.I. compost and those in U.C. mix D were slightly better than those grown in U.C. mix C.

C. alba siberica variegata

A number of plants died after potting up. The U.C. mix D and G.C.R.I. composts with 3:1 peat:sand ratio had nearly three times the number of losses as U.C. mix C. Plant losses also occurred during the overwintering period under glass and late rooting of deciduous plants presents problems.

At the end of the experiment, plants in G.C.R.I. compost looked better than the others, but it was difficult to draw any firm conclusions due to lack of uniformity.

EXPERIMENTS ON THE STORAGE OF TULIP BULBS

Elizabeth D. Turquand, *Kirton Experimental Horticulture Station*

Storage Before Planting in the Field

Until the 1962–63 season no work had been carried out in this country on storage of tulip bulbs for bulb production since the work at Kirton pre-war. All recommendations for storage treatments at that time came from the Netherlands, where conditions were very different from those in the bulb-growing areas of East Anglia.

For the first 3 years, that is up to 1964–65 only Rose Copland was used and storage programmes were designed to examine the effects of certain storage temperatures on this variety.

In 1964–65 the storage treatments compared 17·2°C (63°F) and 20°C (68°F) from lifting to planting, a week at 33·9°C (93°F) immediately after lifting followed by 17·2°C to planting, a month at 25·6°C (78°F) followed by 20°C to planting, and a treatment designed to kill the flowers by giving heat late (blind stoken). The only treatment to have any noticeable effect on yield was blind stoken which increased bulb yield by 20 per cent. This work did indicate, however, that complicated storage regimes might not have the beneficial effect claimed by the Dutch, and that a bulb store temperature of 20°C or 17·2°C may be as good and easier to manage. The Dutch, however, classify tulip varieties into three groups, according to their bulb behaviour, and different storage treatments are recommended for each group. An experiment covering varieties from each group was carried out in which the recommended Dutch storage programme was compared with one supposed to have the opposite effect, and also with a storage temperature of 20°C or 17·2°C from lifting to planting.

Rose Copland, Paul Richter, Elmus and Apeldoorn were selected as representatives of Dutch Group 2, considered normal in behaviour. Demeter and William Pitt were selected to represent Group 3, which are considered to produce too large a bulb and not split sufficiently, while Merry Widow and Paris were used to represent the group which is classified as splitting too much. This experiment ran for two years, 1965–66 and 1966–67. The benefits from the complex storage regimes recommended by the Dutch were slight and storage of 20°C proved just as effective. To complete the programme in 1968–69, Apeldoorn, Merry Widow, Paul Richter and Rose Copland were given simplified storage programmes, comparing 20°C and 17·2°C from lifting to planting, 20°C to mid-September, dropping to 17·2°C until planting, as practised in the tulip store at Kirton, and 25·6°C to 1 August followed by 20°C to mid-September and then 17·2°C to planting.

In the meantime, work on the effects of blind stoken on Merry Widow and Rose Copland continued comparing the traditional method of keeping the bulbs at 27·8°–30°C (82°F to 86°F) for 10–14 days at the end of September and beginning of October with higher temperatures of 31·1°C (88°F) and 32·8°C (91°F) for two and four weeks in mid-August. Work by Mr. Rees at G.C.R.I. had indicated that these temperatures in August give better bulb yields than the traditional blind stoken method; field results have not at present confirmed this, and the kill of flowers was not as good.

Forcing Experiments

When work on tulip forcing began at Kirton it was decided that, owing to lack of published information giving the reasons for Dutch treatments recommended for early forcing, it would be best to investigate these. In the course of this work explanations for failures which occasionally occurred following such treatments might be found, and a firm basis for our own future recommendations would be established.

Since special storage treatments are necessary for the early forcing of tulips, experiments have been chiefly concerned with an examination of these. So far very few varieties have been used in forcing experiments but the stock of bulbs at Kirton is gradually being changed to make a wider selection available. If an experiment is repeated for two years, the time taken to cover more than a few varieties is considerable.

Warm storage for early forcing

A range of storage temperatures and durations was used in 1966–67, the temperatures were 30°C (86°F), 32·2°C (90°F) and 35°C (95°F), and the durations of storage were 2, 7 and 12 days. Varieties used were Apeldoorn, Paul Richter and Rose Copland. This experiment was repeated in 1967–68 when a decision to house Apeldoorn with the flower a little further out of the neck than in the previous year meant that results with this variety were more successful. Apeldoorn and Paul Richter responded to warm storage while Rose Copland did not.

As it seemed possible that bulb stage at lifting might affect the results of the warm storage, and that a rather immature bulb at lifting was necessary for warm storage to be effective, an experiment was started in 1967–68 to explore this subject, using Paul Richter and Apeldoorn. Bulbs were lifted on five dates at weekly intervals beginning on 20 June with storage at 39·9°C (93°F) for a week after lifting. Bulb condition varied from white on the first date to brown with clusters split on the last date. Apeldoorn produced the earliest flowers and best quality from warm stored bulbs lifted on 20 June, while Paul Richter gave the best response with warm stored bulbs lifted on 4 July. These results were sufficiently interesting for this experiment on lifting dates to be extended to include an investigation on the effect of a range of temperature durations on each lifting date. In 1968 bulbs of Apeldoorn and Paul Richter were lifted on four dates and given 2, 4, 6 and 8 days at 33·9°C.

Another experiment begun in 1966–67 and to be continued for five years is exploring the heat requirement of bulbs at lifting in relation to the soil temperatures before lifting. Many forcing difficulties have been explained by attributing them to low soil temperatures in the growing season, and this experiment is designed to investigate these problems. Apeldoorn, Paul Richter and Rose Copland are being used, and the bulbs are lifted, given 0–14 days at 30°C, cool stored, boxed and housed on the same date every year. In the light of experience, in 1967–68 Paul Richter was lifted a week earlier and housed a week earlier, while Apeldoorn was housed a week later than in the first year. So far flowering has been remarkably uniform in date, the only differences being poorer flower quality from the longer periods at 30°C. Results will not be fully analysed until the end of the experiment in 1970–71.

Cool storage for early forcing

Experiments on this subject began in 1965–66. Paul Richter showed no response to temperatures lower than the standard 8·9°C (48°F), while Apeldoorn, Merry Widow and Rose Copland showed some response to cool storage at 4·4°C (40°F) and 6·7°C (44°F) chiefly with longer flower stems. In the 1968–69 season Apeldoorn and Merry Widow are being used to see whether a period at 4·4°C followed by 8·9°C for cool storage might give the benefits of the lower temperature with the better flower quality of cool storage at 8·9°C.

The cool storage treatment demanding most attention, because it might eliminate conventional cool storage if it could be applied to the forcing methods used in this country, is 5°C or direct forcing. When experiments with this method started at Kirton in 1965–66, the American storage temperatures were used, i.e., six weeks at 4·4°C followed by six weeks at 10°C (50°F) prior to planting, and it was called direct forcing because bulbs were planted directly after cool storage in the glasshouse at a temperature of 18·3°C (65°F). Results justified continuance of the work, but by the following year, 1966–67, there was considerable publicity for the Dutch method known as the 5° method (41°F), when bulbs were stored for nine weeks at 5°C before planting in the border. The Dutch and American methods were compared in 1966–67, and since there was little difference in results for the same length of time in cool store, the Dutch method was adopted for future work as being easier to manage commercially. The following year nine and twelve weeks at 4·4°C with and without a week at 33·9°C at lifting were compared. Bulbs of Paul Richter stored at 33·9°C for a week at lifting flowered earlier than bulbs stored at 20°C, and bulbs stored at 4·4°C for twelve weeks flowered quicker than bulbs stored for nine weeks, although flower size was reduced.

Having established that varieties like Paul Richter give reasonable quality flowers if stored at 33·9°C for a week and cool stored for nine weeks at 4·4°C, attention in 1968–69 has been turned to the method of rooting. All the work up to this year has been carried out at Kirton by planting bulbs in boxes on the bench, with the house temperature at 18·3°C. The Dutch do not recommend this method because they say it is important to keep the soil temperature at 15·6°C (60°F) and higher soil temperatures are dangerous. Unfortunately there are no facilities at Kirton for comparing different growing temperatures and therefore different soil temperatures, but an attempt is being made in one house to compare bulbs rooted in boxes of soil on the bench, in water troughs on the bench, and in the border soil with or without soil heating to keep it at 15·6°C. Two dates of starting growth are also being compared: 1 November, which may give flowers before Christmas, and 20 November, which has in the past, from boxes on the bench, given flowers in the week after Christmas.

Short Notes on Other Experimental Work

DATE OF SOWING SPRING CEREALS

N. Forbes, *Arthur Rickwood Experimental Husbandry Farm*

The testing of new cereal varieties for yields is a long established and important process, and this makes a steady contribution to increasing cereal yields in the United Kingdom. Less attention has of necessity been paid to other husbandry factors which might influence yield. As long ago as 1952 however, Boxworth started a series of experiments on the early and late drilling of a single variety of spring wheat; at a later date the series was extended to include different varieties of spring wheat and spring barley.

The Boxworth series of experiments had a particular application for wild oat control on a chalky boulder clay, and the main interest lay in late rather than early drilling. Information on the likely results of early and late drilling on a commercial scale on lighter soils was lacking.

For spring cereals cultivations and drilling may be possible during February, March and April. Against the background of a declining labour force, changes in cereal growing must take place. On soils with a good phosphate status, fertilizer may be spread on the soil surface well before drilling. Bulk handling of seed and fertilizer in the field, implements working in tandem to produce a seedbed at one pass, and wider drills with less idle time, all tend to increase the speed of drilling. It is becoming possible to drill a larger acreage in a shorter time and it therefore becomes increasingly important to reach a right decision about the actual drilling date.

Against a background of changing methods in cereal growing the Boxworth series of experiments was extended in 1966 to a much wider area; Arthur Rickwood, Bridget's, Gleadthorpe and High Mowthorpe started a co-ordinated series of experiments, linked up with work being done at Terrington and the Norfolk Agricultural Station. Closer co-operation was also initiated with similar work being undertaken in three regions by Crop Husbandry Advisers. Considerable data for three years from a variety of differing soil types is now available.

During the three years, no rigid list of spring wheat and spring barley varieties was adhered to. Rapid changes in the N.I.A.B. Recommended Lists, and sudden alterations in disease patterns mean that husbandry factors likely to affect yields must be investigated on current varieties at an early stage if the results are to be of much use to commercial farmers. Thus Opal spring wheat was dropped from the experiment after the 1967 attack of yellow rust and Cambrinus spring barley was tested for only one year at Boxworth in 1966.

Early drilling was possible at all centres. Late drilling can often be accomplished on first-class seedbeds because weather conditions are less likely to interfere with the work. Nevertheless, later in the spring moisture begins to disappear from the top layers of the soil in which the young cereal plant starts its life. At Gleadthorpe, therefore, late drilling was not attempted on a loamy sand soil derived from Bunter pebble beds.

Other husbandry factors were included in the series. All varieties were grown at two levels of nitrogen. At High Mowthorpe there was a special interest in seedbed preparation and seedrate for spring barley drilled on a soil overlying chalk at an altitude of over 400 ft.

The traditional method of evaluating 'quality' in cereals has been by determining 1000 corn weights, but in these experiments a simple standard method for sieving grain samples has been used instead. Quality of grain, more particularly 'tail corn' has been examined by looking at the proportions of the total yield falling in four fractions separated by three standard sieves. Samples from several experiments have shown the effect of late sowing and extra nitrogen on the various proportions.

The combined results from six Experimental Husbandry Farms for three years (1966–68) gave the following mean yields of grain:

Sowing date	*Spring wheat*	*Spring barley*
Early (8 Feb.–11 March)	27·1	35·5
Normal (14 March–1 April)	26·3	34·9
Late (17 April–2 May)	22·4	27·5

Spring wheat stood up better than spring barley to late sowing. For 1966 and 1967, yields from early and late drilling varied about equally, above and below the mean value, depending on the centre. In 1968, a disastrous year for cereal production, early drilling at all centres gave the highest yield and late drilling produced a catastrophic drop in yields.

In only one trial with late drilled spring wheat (Boxworth 1966) was a drop in yield avoided. Late drilling was usually followed by a smaller response to nitrogen and an increased percentage of tail corn.

DATE OF SOWING WINTER WHEAT

W. A. Walker, *Gleadthorpe Experimental Husbandry Farm*

There are three questions to be considered in deciding when to sow autumn corn. Firstly, how does autumn drilling fit into the labour organization at this time of the year? Secondly, what effect does the time of sowing have on disease incidence and grain yield? Thirdly, to what extent does the presence of certain weeds dictate time of sowing, for example, for the need to control black grass on heavy clay soils?

Of these three aspects only the effect of sowing date on grain yield really lends itself to experimental investigation and this was the object of trial work at a number of E.H.F.s in 1957–1962. In this work either September and October, or October and November sowings were compared at any one centre.

Results showed that there was little effect on yield by delaying drilling from September to October, and at Rosemaund the loss in yield by delaying from October to November was 2·6 cwt per acre.

On the stoneless silty loam soil of Rosemaund it was decided to take the work of previous trials a stage further and compare September and October sown wheat. Other factors investigated were seed rates and spring nitrogen

levels. On the loamy sand at Gleadthorpe, work commenced in the autumn of 1966 to study the effect of mid-September, mid-October and mid-November drillings, together with date and rate of nitrogen applications.

Over a five-year period at Rosemaund, drilling wheat in September increased the yield by an average of 1·5 cwt grain per acre compared with sowing in October. This is slightly lower than the improvement obtained from the October versus November sowing in the earlier trials. In the two seasons' work at Gleadthorpe the increase was just over 4 cwt per acre from the September drilling compared with sowing in October. Delaying sowing from mid-October to mid-November reduced the yield by 5·5 cwt.

At both times of sowing at Rosemaund the highest yield of grain was 42 cwt per acre obtained from a seedrate of 1¼ cwt per acre. The small response of 0·3 cwt to 75 units per acre of nitrogen compared with the yield from 50 units was not economically worthwile.

Gleadthorpe's results showed that, provided sufficient nitrogen was used in the spring there was no advantage in applying part of the dressing at the time of autumn sowing, even when drilling was delayed until mid-November. It appears that the optimum nitrogen dressing was 50–80 units applied in the spring.

The evidence so far suggests that sowing date is the one factor which offers the chance of an increase in the yield of winter wheat without additional cost. On the heavier soil at Rosemaund the average increase in yield from early as compared with late sowing has been 4 cwt per acre or 11 per cent. The response on the light sand at Gleadthorpe has been even greater with a 9·5 cwt or 35 per cent increase in yield.

CHLORMEQUAT—THE STRAW SHORTENER

R. G. Hughes, *Regional Crop Husbandry Adviser, N.A.A.S. South Eastern Region*

There is seldom a more depressing scene on an arable farm than that of badly lodged cereal crops. Laid crops lead to frustrations at harvest and if lodged early there is an inevitable loss of grain. The introduction of chlormequat*—a chemical plant growth regulator—was a welcome innovation amongst recent developments in cereal production. It provides a means of shortening and strengthening the straw of some cereal species and thus reduces the risk of lodging. Hitherto its use has been largely confined to wheat although it does offer possibilities for the improvement of the standing ability of some varieties of oats.

Arthur Rickwood, Bridget's, Drayton and Terrington Experimental Husbandry Farms have, together with their colleagues in the N.A.A.S. Soil Science and Crop Husbandry Departments, investigated the potential of chlormequat for the improvement of cereal yields. Since 1965 more than twenty experiments and observation studies have been completed, many of which were carried out on commercial farms. Primarily the aim has been to study the effects of chlormequat on the lodging resistance and yield of wheat under different levels of soil fertility and nitrogen manuring.

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* also known as CCC

Straw Length, Nitrogen and Yield of Wheat

When applied correctly at or near the stage when the first node or 'joint' can be felt on the majority of tillers, chlormequat caused a reduction in length of straw averaging five inches in winter wheat and slightly less in spring wheat. The reduction in internode length was fairly evenly distributed and there was no significant effect on ear length. In all the experiments comparing varietal effect there was evidence that the shorter the straw length initially the greater the reduction caused by chlormequat. Tall strawed varieties of wheat benefited less from the straw reducing properties of chlormequat. Where rates of application of the chemical were compared there appeared to be little merit in increasing the dose above that currently recommended by the manufacturers, i.e., 1½ lb active ingredient per acre (3 pints product) for autumn or early spring sown winter wheat varieties, and half this dose for spring wheat. A higher dose did not significantly improve standing ability and at some centres led to a reduced yield of wheat.

Heavy nitrogen dressings on cereals can increase yields, but all too often cause lodging. It was inevitable that the introduction of chlormequat should lead to interest in its ability to improve the financial returns from nitrogen usage because of its anti-lodging properties. Several of the experiments at E.H.F.s and elsewhere have tested high rates of nitrogen for wheat with and without chlormequat. In general the application of the chemical did not increase the yield of wheat above that obtained when the optimum level of nitrogen was used in the absence of chlormequat. Where benefits did occur, the crop in the unsprayed plots had lodged very early and the difference in yield could be attributed to failure of the grain to fill because the straw was broken. Excess nitrogen above the optimum requirement at any one centre in a particular season, caused a depression in yield whether chlormequat was applied or not. Experiments carried out in Kent showed that chlormequat had a greater anti-lodging effect following early, compared with late, applications of nitrogen. Yield responses were correspondingly greater where chlormequat was used on winter wheat crops to which nitrogen was applied in March or early April, rather than in May.

In a few instances yield increases were obtained following the application of chlormequat despite the absence of lodging in the trial area. This may have been due to an increase in the number of fertile tillers in the sprayed plots because more light penetrated into the shorter, more upright crop, but at two centres the increase was at the expense of smaller grain with a lower bushel weight.

Spring wheat yield responses were similar to those recorded for winter wheat but generally the degree of straw shortening was less. At one centre chlormequat delayed the ripening of Kloka spring wheat and thereby reduced the degree of shedding in what was otherwise an over-ripe crop at harvesting.

Disease Incidence and Weeds

A careful study of disease interaction following the use of chlormequat was carried out at many of the experimental centres. Nowhere was there a clear correlation between the incidence of severe take-all and the application

of chlormequat. The straw straggling effect of eyespot disease in wheat was reduced following spraying at some centres but there was no clear evidence of a reduction in the number of straw lesions at harvest. Sharp eyespot affected one wheat crop in the West Midlands but again there was no correlation with the chlormequat treatment. In South Wales the onset of glume blotch was reported earlier in treated plots of winter wheat and the disease spread more rapidly in the chlormequat plots than in the untreated areas of the crop. The initial build-up of yellow rust was also more evident in treated plots at a few centres in 1967 and this was attributed to the denser, more bushy growth of wheat in these plots producing a more favourable micro-climate for spore development. The progress of cereal foliar diseases is, however, governed by macro-climatic conditions and is often erratic. An early build-up does not necessarily lead to more rapid defoliation and there were no clear indications that the earlier attacks of foliar diseases in chlormequat treated plots affected yields more than in untreated areas of the same crop.

The shortening of cereal straw by chlormequat can allow grass weeds to flourish. At one centre the application of the straw shortening chemical allowed rough stalked meadow grass to double its flowering and seeding capacity in winter wheat. Chlormequat at rates normally recommended for use in wheat has negligible effects on winter or spring germinating wild oats.

Application

The introduction of yet another item into the spray programme may pose problems for the cereal grower already faced with the need to drive across the growing crop to apply a nitrogen topdressing and a herbicide. A series of experiments carried out in 1967 tested the effect of spraying tank mixtures of various herbicides with chlormequat, and at two centres in Cambridgeshire liquid nitrogen (40 and 60 units per acre) was also added. The range of herbicides included MCPA, dichlorprop, mecoprop and mixtures of TBA or bromoxynil with MCPA. No difficulties were experienced during mixing or application, and the addition of these herbicides as a tank-mix did not adversely affect the straw shortening efficiency of chlormequat. In a few instances the herbicides alone reduced the straw length of wheat by 1 or 2 inches, but chlormequat caused a further reduction of 3 to 5 inches. Applying the materials as a tank mix had no different effect on grain yield from applying them separately, but mixing does raise an issue regarding the optimum time for spraying, since delaying the application of herbicides to meet the requirement of chlormequat could allow weeds to become firmly established and therefore less susceptible to the herbicides. Where liquid nitrogen was added to the spray treatment a marked leaf curl occured in the crop within minutes of application, followed by a distinct scorching a few days later.

Other Cereals

Winter oats were treated with chlormequat at three centres using 1½ lb active ingredient per acre. Application was either at the first or second node development stage of the crop. With Peniarth winter oats the results were disappointing, because there was very little reduction in straw length and no reduction in lodging. More encouraging results have been obtained

with Maris Quest but the use of chlormequat in oats needs further investigation. There are indications that best results are obtained when application is delayed until the crop reaches the second node growth stage, when unfortunately a considerable amount of wheel damage may result from a ground crop sprayer.

Observation studies at one E.H.F. and in two commercial crops indicated that even at high rates of application chlormequat had little effect on the straw length of currently popular varieties of spring barley or their susceptibility to lodging.

SUCKLER HERD INVESTIGATIONS AT E.H.F.s

R. B. Mair, *High Mowthorpe Experimental Husbandry Farm*
T. L. Powell, *Liscombe Experimental Husbandry Farm*
J. D. James, *Trawscoed Experimental Husbandry Farm*

There has recently been an extension of interest in suckler cow herds. Five Experimental Husbandry Farms currently have suckler herds, and some of the experimental work in progress in three of them is described below in relation to the context in which it was initiated. Of the other two herds, one is at Redesdale in Northumberland, which has only recently been taken over; the other is at Pwllpeiran, on the slopes of Plynlymon in Wales, where crossbred Galloway x Welsh Black and purebred Welsh Black herds are being established for comparative purposes.

High Mowthorpe

The possibilities of keeping a single suckler herd to utilize permanent grassland on an arable farm are under investigation at High Mowthorpe. The 40 acres of steep unploughable dale land on the farm would normally be utilized to provide summer grazing for the ewe flock, but low profits from sheep have meant that many farms are looking for an alternative stock enterprise.

The low labour requirement of single suckling herds could make them an attractive stock enterprise on arable farms, provided they can be managed so that they leave a reasonable return on land and capital. The objective at High Mowthorpe has therefore been to keep management simple and reduce costs to a minimum.

The cows are stocked at approximately one per acre of grass. The winter feeding is based on barley straw, supplemented by rolled barley, plus minerals and vitamins. This method of feeding means that no silage or haymaking is needed to supply fodder for the cows. Grazing control is also kept as simple as possible, the dales having been split into paddocks of around 7 to 10 acres in size, by using double strand barbed wire fences. The fences have been erected so that each paddock contains some land that is level enough to allow a fertilizer distributor to be used. Between a third and a half of the land is given basic slag and top dressings of up to 200 units of nitrogen per year, whilst the steep inaccessible slopes receive no fertilizer.

The cows are moved from paddock to paddock as grass growth demands, but the calves quickly learn to creep through the fences and get the pick of the grazing.

The Hereford × Friesian cows are mated to Lincoln Red Bulls, about 20 cows calving in January–February each year and a similar number in July–August. The spring calvers run with their calf throughout the summer until August. The average weaning weight of these calves has been 416 lb. After weaning they graze on leys whilst the cows remain on the permanent grass until yarding in November. This early weaning is essential as the cows must be given an opportunity to gain weight and condition before yarding, as the winter feeding supplies only a bare maintenance ration.

The summer calvers are turned out of yards in March and have some four months grazing in which to recover from suckling their calves through the previous winter. The calves remain inside for a further month before being turned out on to leys. With good grass available the best of the calves have gone fat off grass at around 12 months old, and the remainder are yarded to be finished before Christmas when 16 to 18 months old.

The enterprise was established in 1966, when the stock were purchased as bulling heifers, and each herd has calved down twice. The calves have made good progress and have finished well, realising an average of £84 per head, including calf subsidy. With a winter feed cost of approximately £15 per cow, for 7 cwt of barley and 30 cwt of barley straw, the potential margin per cow per year should be in the region of £40.

In 1967/8 the margin was reduced to £20 per cow because poor conception resulted in the calving index being 15 months, instead of 12 months. The poor conception rate may have been partly due to the low level of winter feeding but with little change in the management all 34 cows put to the bull in May 1968 conceived. As conception can have such a profound effect on profit it is obviously too early to draw any firm conclusions from the High Mowthorpe results.

Apart from the uneven conception rate, the spring calving herd have presented very few difficulties in management. The summer calvers have been rather more prone to trouble and a severe outbreak of hypomagnesaemia resulted in the death of two cows in October 1968. Summer mastitis and nutritional scour were expected to be potential hazards with cows calving in July or August, but have not been experienced to date at High Mowthorpe.

Liscombe

Part of any increase in home beef production must be from suckler herds. Unless management and stock are of a very high standard, it is difficult to justify the existence of these herds on anything but the poorest land. Liscombe, which lies on the edge of Exmoor, has recently expanded its beef herd and investigations are under way into methods of improving the efficiency of suckler enterprises on upland farms.

In milk production raising stocking rates can lead to great improvements in profitability. In order to study the effect of intensification upon output from a spring-calving single suckling herd, a trial was commenced in 1967 and will continue until at least autumn 1970. Four 13-cow herds are involved, each herd being maintained for the major part of the year at a particular

combination of nitrogen and stocking rates. The cows, which are either Devon or Devon x Friesian, are housed from mid-December until shortly after calving which occurs between early February and late April. Calves are sired by a Devon bull.

Results to date indicate that calf performance to weaning does not deteriorate at the highest level of intensification (1 acre per cow; 160 units N per acre), but that profitability is not likely to better than that achieved at $1\frac{1}{4}$ acres per cow with 60 units of N applied per acre, unless conservation of grass surpluses is very efficient. The trial illustrates an advantage of the cross-bred cow under the particular conditions in that the calf is about 1 cwt heavier than the pure-bred at weaning in mid-October.

The winter feed bill of the cow is an obvious target for any attempt to reduce costs in suckler production. Current work is attempting to determine the extent to which body reserves can be used up during pregnancy without adversely affecting subsequent performance of cow and calf. Such basic information is necessary before the highly important subject of winter feeding can be adequately investigated. The opportunity has also been taken to measure the appetite for silage of Devon and Devon × Friesian cows. The crossbreds ate 10 per cent more silage than Devons of comparable weight fed silage alone, but this was increased to 20 per cent when 4 lb of barley per head per day was provided.

Although a large number of suckled calves are sold at the well publicised autumn sales, the majority are disposed of in other ways. Investigations in the 1967–68 winter were aimed at providing information which would tell the producer whether, at the price offered in the weaned calf sale, he would show more profit by retaining and fattening the cattle on a high concentrate ration. Even though the 'barley beef' system has many advantages, particularly on more heavily stocked farms, calves can finish at undesirably low weights and current work is concerned with store planes of nutrition for weaned calves as well as certain aspects of feeding high concentrate rations.

Trawscoed

It is estimated that pure bred Hereford suckler calves comprise 30 per cent of the calves presented for sale at the weaner calf sales held in October in the Brecon area. The profitability of single suckling is closely dependent on the price received for the weaned calf as this is the sole output of the enterprise. Although considerable expertise has been developed in the marketing of weaned calves via such sales, calves lighter than about $4\frac{1}{4}$ cwt are still difficult to sell. In order to achieve this weight and make an acceptable price, calves born in March and April must have a high birth weight and good growth rate.

A survey into various aspects of the management of single suckler herds carried out by the National Agricultural Advisory Service in Brecon in 1960–61 showed that 57 per cent of calvings occurred in March and April, while the longer period February to May accounted for 71 per cent of calvings. Spring calving herds were therefore in the majority. Within them there was a very wide range of winter food costs for the cows depending on the level of feeding practised, but where calving was in March and April average food costs were half those of September and October calving herds.

Whole crop cereal silage
Barley being cut in late July by a self-propelled forage harvester for ensilage in a tower silo.

HIGH MOWTHORPE EXPERIMENTAL HUSBANDRY FARM

Whole crop cereal silage
Barley being mown in late July for whole crop cereal silage.

Whole crop cereal silage
Barley mown for ensilage being almost immediately collected by a double-chop forage harvester, fitted with a pick-up attachment.

ROSEMAUND EXPERIMENTAL HUSBANDRY FARM

Intensive sheep production

Winter accommodation for 300 ewes has been erected by farm labour at a total cost of £300, excluding the racks.

GREAT HOUSE EXPERIMENTAL HUSBANDRY FARM

(Photo: Farmers' Weekly)

Grassland manuring

Weighing the produce off a plot receiving the equivalent of 600 units of nitrogen per acre per annum at 800 ft above sea level.

PLATE II

Semi-intensive rearing of spring calves for beef

Five-month old March-born Friesian steers grazing a ryegrass ley, having been paddock grazed from 6 weeks of age.

(Photo: Farmers' Weekly)

Fifteen-month old Hereford x Friesian heifers fattening on a first-year ryegrass ley in June.

PLATE III

HIGH MOWTHORPE EXPERIMENTAL HUSBANDRY FARM

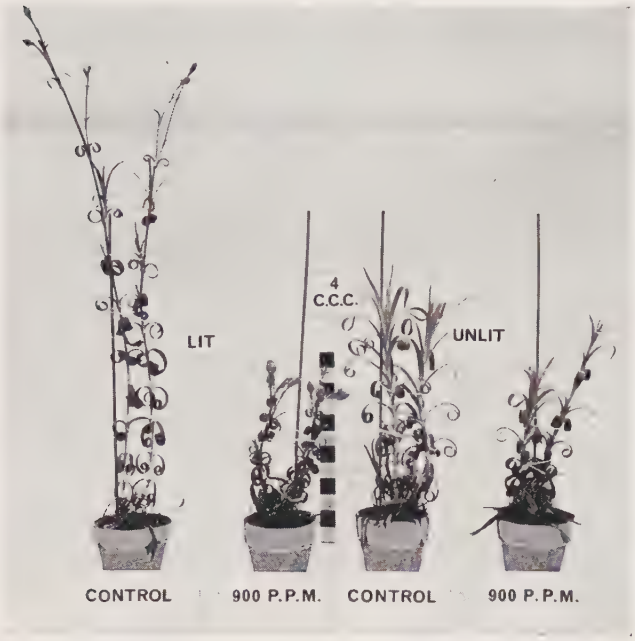
Intensive cereal growing

General view of farm showing continuous wheat experiment in middle distance, with ewes and lambs paddock grazing beyond.

GLEADTHORPE EXPERIMENTAL HUSBANDRY FARM

Minimum labour sugar beet

Band spraying herbicide over sugar beet rows as they are sown by a five-unit precision drill.



Cycocel applied at 0·9% a.i. on four occasions compared with control plants with eight weeks of continuous lighting on left and natural daylength on right. Rooted cuttings potted 11 September 1968; photographed 10 March 1969.

Three plants of the variety Bailey's Apricot potted into a $5\frac{1}{2}$-in. half-pot.

PLATE V

FAIRFIELD EXPERIMENTAL HORTICULTURE STATION

Heat therapy unit constructed for treatment of chrysanthemum stock.

STOCKBRIDGE HOUSE EXPERIMENTAL HORTICULTURE STATION

(Photo: Hugh Collip)

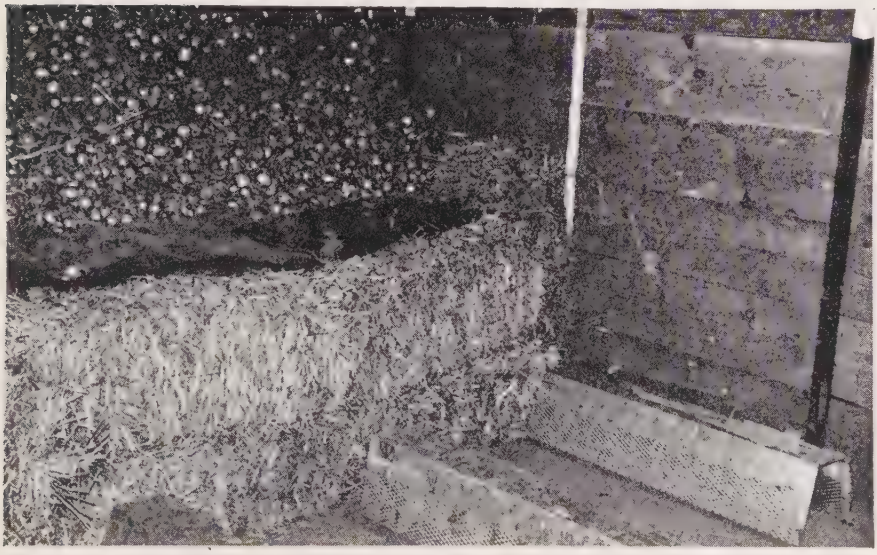
Laying tiles for underground steaming mains: note covering of chippings followed by coarse peat prior to replacement of soil.

PLATE VI

ROSEWARNE EXPERIMENTAL HORTICULTURE STATION

Early potato plants showing coiled sprouts, variety Home Guard.

KIRTON EXPERIMENTAL HORTICULTURE STATION



Onions in store showing unloading in progress; in foreground sections of ducting used for ventilation of onion stack.

PLATE VII

FAIRFIELD EXPERIMENTAL HORTICULTURE STATION

Tomato propagation: a standard plant raised in a glasshouse under normal conditions compared with plants which received growing room treatment.

LEE VALLEY EXPERIMENTAL HORTICULTURE STATION

Aubergine plant, photographed 12 August: note very vigorous growth and excellent crop.

PLATE VIII

Some of these differences of management and feeding are being investigated in an experiment at Trawscoed E.H.F. One of the objects is to discover whether high level feeding of the spring calving suckler cow up to the point of first calving influences the weight of spring-born calves sold. 36 Hereford heifers, single suckled for the first six months of their lives were purchased. 24 of these heifers were obtained from four sires in 1962 and were divided into two groups. Twelve heifers by the same sires were then purchased in 1963 to form a third group. The rearing of each group was as follows:

Group 1 A high plane of nutrition and first calving at three years old.
Group 2 A low plane of nutrition and first calving at three years old.
Group 3 A high plane of nutrition and first calving at two years old.

TABLE 1

Levels of rearing of suckler heifers

Group Age at first calving Plane of nutrition during rearing	1 3 years High	2 3 years Low	3 2 years High
Summer 1962	Single suckled before purchase	Single suckled before purchase	—
Winter 1962–63	D.L.W.G. 1 lb inwintered	maintenance only inwintered	—
Summer 1963	D.L.W.G. 1½ lb at grass	D.L.W.G. 1 lb at grass	Single suckled before purchase
Winter 1963–64	D.L.W.G. 1 lb inwintered	maintenance only outwintered	D.L.W.G. 1 lb inwintered
Summer 1964	D.L.W.G. 1½ lb at grass	D.L.W.G. 1 lb at grass	D.L.W.G. 1½ lb at grass
Winter 1964–65	D.L.W.G. 1 lb outwintered and steamed up	D.L.W.G. 1 lb outwintered and steamed up	D.L.W.G. 1 lb inwintered and steamed up
Summer 1965	At grass suckling calf	At grass suckling calf	At grass suckling calf

The ration in the first winter for the high plane heifers was 12 lb hay and 8 lb meal daily, while the low plane heifers received 10 lb hay and barley straw daily. During their second winter the low plane heifers were outwintered and fed silage while the high plane heifers were fed on silage plus three pound of meal daily. In the third winter immediately before calving both groups of older heifers were outwintered and fed on silage. The heifers due to calve at two years old were inwintered and fed 4 lb of meal per head

per day. After calving all cows received 6 lb per head of meal daily until grass was available.

Heifers in each of the three groups were mated to the same Hereford bull and first calved down in February and March of 1965. During each subsequent summer all the sucklers plus calves grazed reseeded hill land until mid-October when the calves were weaned. Each winter silage was easy fed from December to calving. Steaming up with 4 lb magnesium cobs per day commenced at the end of January.

Three crops of calves were taken from the cows and for any one year all three groups were mated to the same Hereford bull.

The cost of rearing on a high plane of nutrition to first calving at three years old was £56. The cows fed on the lower plane of nutrition cost £37 to rear, while those fed on a high plane to first calving at two years old cost £33 to rear.

The live weight changes of heifers between six months of age and the third calving are shown in Table 2.

TABLE 2

Suckler weights and weight gains to third calving (lb)

Group	1	2	3
Age at first calving	3 years	3 years	2 years
Plane of nutrition during rearing	High	Low	High
Wt. at start of winter 1962–3	439	449	—
Wt. at end of winter 1962–3	626 (1st year)	456 (1st year)	—
D.L.W.G., winter 1962–3	1·1	0·04	—
Wt. at end of summer 1963	880	752	459
D.L.W.G., summer 1963	1·6	1·8	(1st year)
Wt. at end of winter 1963–64	1014 (2nd year)	837 (2nd year)	636
D.L.W.G., winter 1963–64	0·7	0·5	1·1
Wt. at end of summer 1964	1266	1142	870
D.L.W.G., summer 1964	1·3 (3rd year)	1·6 (3rd year)	1·2 (2nd year)
Wt. at first calving, spring 1965	1146	1101	901
Wt. at second calving, spring 1966	1081	1061	918
Wt. at third calving, spring 1967	1143	1096	1017

Despite fairly hard rearing conditions the low plane heifers weighed almost as heavy as the high plane heifers in Group 1 by three years of age. In spite of a high plane of nutrition the heifers which initially calved at two years of age were slightly smaller, and at four years of age (third calving) were still lighter than the heifers in the other two groups when they first calved at three years old.

The liveweights of the calves at various stages are given in Table 3.

TABLE 3
Calf weights (lb)

	At birth	At 56 days old	At 105 days old	At end of August
First calving:				
High plane—group 1	83	137	209	320
Low plane—group 2	79	133	213	331
High plane—group 3	69	116	181	275
Second calving:				
High plane—group 1	74	159	240	296
Low plane—group 2	74	144	219	251
High plane—group 3	77	149	236	289
Third calving:				
High plane—group 1	85	163	245	350
Low plane—group 2	83	158	233	320
High plane—group 3	71	134	210	286

Apart from the second calving when birth weights on all treatments were similar, the heifers calving initially at two years of age produced lighter calves. Subsequent growth rates of the calves varied between 0·83 and 1·58 lb per head per day, with season and treatment. Although trends in daily live weight gain were not always consistent, calves from cows calved initially at two years old tended to grow less quickly. At 56 days and 105 days the calves from the high-plane three-year-old group of cows tended to be heaviest and those from the high-plane two-year-old group the lightest. The two-year-old calving heifers were also the least productive when measured by mean calf weight at the end of August over the three year period of the experiment. The difference between Groups 1 and 2 in this respect were small, the calves from cows in Group 1 being on average heavier by 21 lb per calf. This suggests that a heifer reared on a high plane of nutrition will probably produce annually a calf worth only £1 15s. 0d. more than the calf produced by a heifer reared on a low plane and calved at the same age.

The Group 3 heifers were lighter at each calving than either of the two older groups, but this weight differential narrowed with each successive calving. The performance of calves born to Group 3 heifers was slightly poorer than that of the others at the first and third calvings, but was better than Group 2 and almost as good as Group 1 at the second calving. The breeding performance over three calvings recorded in the trial did not indicate any detrimental effect on the dams from early first calving.

By calving heifers at two years of age, although the growth rate of the calves born may be slightly depressed at least in some seasons, there will be the distinct advantage of gaining one extra calf in the lifetime of each dam. This represents an increased production ranging from 33 per cent where herd life is three calvings down to 16 per cent where herd life is normally six calvings. This increased production would help to offset the charge for the extra inwintering accommodation necessary for early calving heifers.

Of the 36 heifers which started the experiment, 31 calved their third calf. In Group 1 two heifers failed to breed while in Group 2 one was barren and one died of a severe respiratory condition, and in Group 3 one was barren.

TABLE 4

Changes in weight of suckler cows (lb)

	First calving	Second calving		Third calving	
	Calving to weaning	Weaning to calving	Calving to weaning	Weaning to calving	Calving to weaning
Group 1—high plane	+ 97	−162	+247	−185	+70
Group 2—low plane	+ 79	−119	+233	−198	+38
Group 3—high plane	+121	−102	+225	−108	+34

An important feature of this trial has been the capacity of cows in each of the treatment groups to gain substantial weight during the suckling period, which indicates that their nutrition at grass during the summer months has been more than adequate. This tendency to gain weight need not be a disadvantage, particularly in districts where summer pasture is abundant and weather conditions make conservation difficult. The capacity of the cows to live 'off their back' during the winter has been clearly seen and substantial losses of weight have occurred between weaning and spring calving without serious effects.

THE MANAGEMENT OF YOUNG BEEF CATTLE GRAZING PASTURE INFECTED BY STOMACH WORMS

S. C. Meadowcroft, *High Mowthorpe Experimental Husbandry Farm*

To secure a high output from grassland through young beef cattle they must be grazed at a high stocking density. Such animals often make good liveweight gains during the early weeks of the grazing season, but do relatively badly from July onwards. Poor performance in the second half of the grazing season may be due to a variety of factors but in many farm situations infection with intestinal trichostrongylid worms is undoubtedly one of the causes of unthriftiness.

Many of the previously recommended control measures, such as rotational grazing or regular anthelmintic dosing of cattle at grass are likely to be ineffective. Recent research work on the life history of these parasitic worms has suggested that these techniques should be replaced by more appropriate management methods.

It is now appreciated that rotational grazing will not prevent the build-up of the number of infective larvae in the sward. This infestation can reach a level in July which will affect the health and progress of the grazing cattle. J. F. Michel of the Central Veterinary Laboratory, Weybridge, has suggested that this situation can be avoided, if cattle are moved in mid-July on to pasture previously ungrazed during that season. An anthelmintic dose at the time of moving might increase the effectiveness of the move on to clean grass, by reducing the rate at which pasture infection is built up.

Michel's results, from calves turned out to grass at approximately 150 lb live weight, showed an advantage to the calves dosed and moved to aftermath grass in July. The extra live weight gain at grass was 61 lb per calf in 1964 and 146 lb per calf in 1965, over the gains of calves which grazed the same paddocks throughout the season with no anthelmintic treatment. It was decided to test this system on Experimental Husbandry Farms and trials commenced in 1967.

The E.H.F. Trials

So far trials have been carried out at High Mowthorpe and Gleadthorpe E.H.F.s in 1967 and 1968, and at Rosemaund and Drayton E.H.F.s in 1968 only. At three of the farms Friesian or Hereford × Friesian steers, seven to nine months old, have been used in the trials. At the fourth farm, Gleadthorpe, spring born calves were turned out to grass at approximately 9 weeks of age. All the leys used were known to be infected with parasitic worm larvae.

The treatments compared have been:

(1)	Grazed same paddocks throughout season.	No anthelmintic dosing.
(2)	„ „ „ „ „	Dosed with thiabendazole mid July.
(3)	Grazed fresh aftermath only from mid July.	No anthelmintic dosing.
(4)	„ „ „ „ „	Dosed with thiabendazole mid July.

There were two additional treatments at Rosemaund. In these, cattle were grazed from mid-July on grass which had earlier been grazed by frequently dosed cattle. It was therefore soiled by dung and urine but was virtually free of infective parasitic larvae.

Live weight gain per beast per day from mid-July to yarding (lb)

Treatments	High Mowthorpe		Gleadthorpe		Rosemaund	Drayton
	1967	1968	1967	1968	1968	1968
(1) No move. No dose	2·00	1·70	2·09	1·77	0·47	1·29
(2) No move. Dosed	1·79	1·68	2·04	1·58	1·06	1·12
(3) Moved. No dose	1·27	1·66	1·98	1·79	1·47	1·77
(4) Moved. Dosed	1·46	1·62	2·29	1·80	2·04	1·37
(5) Moved to soiled grass without parasites. No dose					1·17	
(6) Moved to soiled grass without parasites. Dosed					1·57	

In all the trials records have been kept of the live weights of animals, worm egg counts in the faeces, and numbers of worm larvae in samples of herbage.

The results have been extremely variable. This can be seen from the table on page 55.

Effect of Move to Fresh Aftermath in July

At Rosemaund and Drayton the grazing of aftermaths had a very beneficial effect on liveweight gain. At High Mowthorpe there has been no advantage, but there was provision of aftermath grazing for cattle which continued to have access to the spring grazed paddocks (treatments (1) and (2)). It seems possible that the provision of some grass free of infective larvae may have reduced the worm burden of grazing animals by a 'dilution' effect. At Gleadthorpe with the younger calves there has been no consistent advantage in grazing only aftermaths, but levels of infestation with worms have been low on this farm so the lack of response was predictable.

Effect of Anthelmintic Treatment

There has been little evidence to show that animals which continue to have access to pasture infected with worm larvae gain any advantage from an anthelmintic dose in mid-season. Presumably these cattle become re-infected again at once.

When animals have been moved on to clean aftermath in July, an anthelmintic dose at the time of the move has given an advantage in subsequent growth rate in four trials out of six. These animals were moved to aftermath grass which had a very low level of parasitic infection, and the apparent effect of the anthelmintic dose was to slow down the increase, from July onwards, in the number of parasitic larvae in the aftermath herbage. Giving anthlmintic treatment in mid-July and moving at this time to fresh aftermath grazing until the end of the season, has given the best performance in three of the six trials so far completed. Support for the Weybridge results has appeared in a recent report on the grazing method employed on 55 Dutch farms, which has recommended that cattle should be systematically grazed on aftermaths. The work on Experimental Husbandry Farms is continuing in 1969.

BEEF FROM BRED HEIFERS

M. B. Helps, *High Mowthorpe Experimental Husbandry Farm*

In England and Wales approximately 25 per cent of the beef cattle marketed are clean heifers. These animals could provide a source of beef calves if they were allowed to breed before slaughter.

For this reason the technical feasibility and potential profitability of beef production from bred heifers are being investigated at Boxworth and High Mowthorpe.

High Mowthorpe Trials

At High Mowthorpe two intakes were made in 1964 and 1965. April born Hereford / Friesian heifer calves were purchased at 10 to 14 days old and reared on an early weaning system. They were turned out to grass as soon after weaning as possible. The feeding of early weaning concentrates was continued at grass but by 12 weeks after arrival the concentrate supplement was reduced to a daily ration of 1 lb rolled barley plus 5 per cent mineral supplement.

The heifers were yarded in October when weighing around 300 lb liveweight at 8 months old. It was felt that a high rate of gain was needed during the first winter in order to bring the heifers to a suitable weight of 650 to 700 lb when served at just over a year old. They were therefore gradually introduced to a high cereal diet and were for a time fed to appetite on a cereal and protein mixture. Hay or high dry matter silage was also on offer. Liveweight gains in excess of 2 lb per day were achieved during this period.

In March the concentrate ration was reduced to 8 lb per head per day and high dry matter silage was fed to appetite. Twelve heifers, from the 1964 intake, ran with a Hereford bull from 26 March to 19 June, 1965. Thirteen heifers, from the 1965 intake, ran with a Lincoln Red bull from 3 May to 25 July, 1966. Twenty-four out of the total of twenty-five heifers conceived.

After turnout, in early May, the cattle grazed on permanent pasture, throughout their second summer. The barren heifer was sold fat off grass in September 1965. The remaining heifers were yarded in November on to rations based on silage. Rolled barley, at 3 lb per head per day was fed until about a month before calving. At this stage it was apparent that the high condition of the heifers could lead to difficulties at calving and the supplementary barley feed was stopped. The heifers then received only silage fed to appetite until they had calved.

Management after calving was different in the two years. In 1966 the eleven heifers that conceived produced ten live calves. The weight of these calves at birth ranged from 59 lb to 78 lb and calving was relatively easy. One calf, weighing 82 lb, was born dead. The calves ran with their dams for an average of 51 days and had an average daily gain of 1·4 lb per head from birth to weaning. The average weight of the calves at weaning was 139 lb.

Whilst the heifers were suckling their calves the intention was gradually to build up the concentrate ration in order to maintain them in good body condition ready for early slaughter after weaning. It was found that any attempt to do this earlier than four weeks after calving stimulated milk production to a level that caused scouring in the calves. Feeding after calving was therefore largely restricted to hay. The heifers lost an average of 52 lb liveweight while suckling their calves and a further check occurred when feed and water were restricted during the drying-off period. The net result of this was that an average of 46 days after weaning were needed on a daily ration of hay and up to 8 lb of rolled barley to bring the heifers into a satisfactory condition for slaughter.

The average liveweight of the heifers at sale was 970 lb, 8 lb less than their weight immediately after calving. However, the calves made an average

liveweight gain of 71 lb in the 97 days between birth and the sale of the heifers.

The problems resulting from the attempt to keep the heifers in good condition whilst they suckled their calves led to a decision to change the management with the second batch of 13 heifers which calved in 1967. The calves were left on the heifers for only two days before being removed and reared on milk substitute. The heifers were then dried off on a restricted diet of hay for 7 days. They were finished on a ration of 6 lb of rolled barley per head per day plus silage to appetite and were sold at an average liveweight of 1,003 lb on average 32 days after calving.

The average weight of these heifers at calving was 967 lb, similar to that of the first group, but they gave birth to bigger calves. Average birth weight was 80 lb, 12 lb heavier than in 1966, and calving was much more difficult. Four of the thirteen calves were either born dead or died during calving. Three of these weighed between 95 lb and 100 lb and were only delivered after veterinary help was obtained. The calving difficulties may have been partly due to the Lincoln Red bull producing larger calves than the Hereford, but were also felt to have been caused by the high plane of nutrition of the heifers prior to calving. Similar heifers in the suckler herd at High Mowthorpe have produced Lincoln Red cross calves without abnormal calving trouble when kept in lean condition by restricted feeding.

Boxworth Trials

A total of 16 calves born in October and November 1966 were used at Boxworth E.H.F. Half were home bred Angus × Friesian and half were purchased Hereford × Friesian heifers. All were reared on an early weaning system and were successfully inseminated with Polled Hereford semen in January and February 1968.

Four of each cross were yarded throughout the trial, the remainder being turned out to grass. These animals were turned out from May until October 1967, and from April until October 1968.

Feeding in yards was based on 4 lb to 8 lb of concentrates per day, plus hay or straw. The animals calved inside during October and November 1968. The calves were removed soon after birth and sold. The heifers were sold three weeks after calving.

The average birth weight of 13 calves (excluding one born prematurely) was 82 lb. Average liveweight of the heifers at sale was 988 lb.

Conclusions

These trials demonstrated the feasibility of producing a calf from a beef heifer before it is slaughtered at 2 years old. The main technical hazard is the need for a high plane of nutrition which can very easily result in overlarge calves and consequent calving difficulties. It has also been found that the acreage requirement per beast is relatively high. At High Mowthorpe the production of a bred heifer utilized a total of 2 acres of grassland, and the levels of liveweight gain per acre which can be achieved are not high compared to the output which can be obtained from grassland devoted to other systems of semi-intensive beef production.

The costs of production of the groups of bred heifers described above are shown in the following table:

	High Mowthorpe		Boxworth	
	1964	1965	1966 Grazed	1966 Yarded
No. of heifers	12	13	8	8
No. of live calves	10	9	7	7
No. of days to calving*	649	681	713	716
No. of days to sale*	746	713	734	737
Total variable costs per head including forage cost but excluding calf cost	£51.18s.	£52.0s.	£55.1s.	£86.18s.

*Calculated from date of purchase at High Mowthorpe and date of birth at Boxworth.

The yarded group at Boxworth was obviously uneconomic but there was a high degree of uniformity in the variable costs of the other three groups.

Conventional beef systems are capable of producing gross margins of £25 per acre from a suckler herd or £40 per acre from 18 months semi-intensive beef. With the results achieved in these trials it would have needed a beef price of over 240s. per cwt to achieve a gross margin of £30 per acre from bred heifers. In practice the prices obtained ranged from 144s. to 170s. per cwt for well finished fat heifers.

As they had calved, the heifers were not eligible for payments under the Fatstock Guarantee Scheme. Loss of this payment did not account for more than 25 per cent of the difference between the price received for bred heifers and that received for similar cattle which had not calved. The other 75 per cent must be attributed to a lack of enthusiasm in the meat trade for the bred heifer.

It is difficult to see bred heifers competing with the most profitable semi-intensive beef production systems at present price levels.

SEMI-INTENSIVE REARING OF SPRING BORN CALVES FOR BEEF PRODUCTION

J. M. Willcock, *Liscombe Experimental Husbandry Farm*

Over a decade has elasped since the early weaning system of rearing calves was introduced. As a method of calf rearing it was rapidly taken up by the farming fraternity and is now used as a basis for rearing the majority of calves from the national dairy herd destined for beef. The system is really based on changing the young calf into a ruminant at an early age and so shortening the period of liquid feeding of relatively expensive milk substitute. It was known that young grass was highly digestible and so the next logical step was to see if it would be possible for the young calf to make use of grass from an early stage.

Rearing at Grass

The results of research work undertaken at the Grassland Research Institute at Hurley indicated that calves could be satisfactorily reared at grass from approximately 7 days of age. Soon after, in 1961, trials began on two of the Experimental Husbandry Farms. At High Mowthorpe on the Yorkshire Wolds, comparisons were made between inside and outside rearing of April born Friesian steer calves. Milk substitute was fed until 3 weeks after arrival along with concentrates. Hay was on offer to the group inside but not to those outside, in order to encourage them to graze. A third group, reared outside, were fed milk substitute up to 7 weeks after arrival and a little hay for the first 3 weeks, but no concentrate. Galvanized iron shelters were provided for the calves reared outside. Calf performance varied considerably, some doing well and others poorly, but nevertheless, valuable experience was gained. Some of the calves reared outside which were weaned after 3 weeks on milk substitute checked badly, and this was thought to be due to their not having learned to eat sufficient concentrates or grass by the time milk feeding stopped. Others which had taken to concentrates, suffered little or no check, neither did any of those fed on milk substitute for 7 weeks which were not allowed concentrates.

In subsequent rears, milk substitute feeding always continued for 5 weeks after arrival, by which time all calves had learnt to eat concentrates when offered and to graze well. These methods of rearing produced satisfactory calves, provided prolonged wet weather did not restrict grazing. Calves reared inside until weaning and then turned out still with access to concentrates did not check.

Although it was found possible to rear April born calves outside, the task of carting milk substitute and the need to erect feeding facilities and calf shelters suggested that in most circumstances it would be more practicable to rear inside and turn out to grass at 5 to 6 weeks of age, especially if large numbers were involved.

One technique of rearing calves for beef production has followed similar lines on Liscombe Experimental Husbandry Farm, an upland farm in North West Somerset. March and April born calves have been reared inside and turned out to grass at approximately 6 weeks of age. Calves continue to receive as much early weaning concentrate as they will clear up in two feeds daily until they are grazing well. After 2–3 weeks and when there is sufficient grass, concentrates are restricted to one feed of 3 lb per head per day and from approximately 3 months of age until the end of the grazing season, between mid-October and mid-November, no concentrates are fed. Performance during the calf grazing season at both farms has been in the order of $1\frac{1}{2}$–2 lb liveweight gain per head per day.

Supplementary Feeding

Although increased liveweight gains have sometimes resulted from supplementary feeding, this has not proved economic when there is adequate grazing. At Liscombe with March born beef × Friesian steer calves, no additional liveweight gain resulted from feeding a daily ration of $2\frac{1}{2}$ lb rolled barley from 12 weeks of age in early June until mid-October. At a similar level of feeding a 3:1 barley:protein mixture gave a slightly better

performance. This only amounted to an additional $\frac{1}{4}$ cwt liveweight by the end of the grazing season from feeding $2\frac{1}{2}$ cwt per head of the supplement. Similarly at High Mowthorpe, where the average annual rainfall of 30 inches is only half that at Liscombe, the effect of supplementary feeding has been small. However, at High Mowthorpe it is now usual practice to feed a pound of barley to act as a carrier for a mineral supplement right through the grazing season. If conditions for grass growth become adverse, for example as a result of lack of rainfall, then this supplementary ration is easily increased. It has also been the practice in recent years to increase the level of cereal feeding at grass prior to calves coming into yards onto high concentrate rations to finish at approximately 12–14 months of age. This ensures a more gradual change over from one system to another and reduces the risk of nutritional upsets.

Grassland Management

Young calves need high quality leafy pasture in order that they continue to grow and gain weight without check. These conditions are easily attained in the spring and early summer but some degree of skill in grassland management is necessary in order to maintain pasture of high digestibility during the second half of the grazing season when grasses naturally tend to head and fall off in quality.

On both farms some form of paddock grazing is practised so that control of pasture quality can be maintained by topping after grazing if necessary, and by regular fertilizer applications.

Due to their freedom from parasites, new leys are ideal for rearing calves. It may however be impracticable to have a succession of new leys on mainly grass farms and an alternative which has worked quite well has been to rear calves on a pasture one year and graze with sheep another. It would appear desirable to avoid grazing young calves after ewes and lambs in the same season as some parasites are common to both cattle and sheep and calves have been known to become infected in this way. Recent experimental work suggests that if calves are turned out onto winter rested pastures, only a slow build-up of parasitic infection takes place in spring. This build-up can, however, reach a dangerous level by mid-July. The use of a modern anthelmintic and a change to conservation aftermaths at this stage reduces the risk of any fall off in liveweight performance resulting from parasitic infection. Aftermath grazing is also usually of high nutritional quality and having been cut for conservation is free from fouling and is therefore more readily and cleanly grazed.

Stocking Rates

It is difficult to be precise regarding stocking rates due to the large variations in appetite between young freshly-weaned calves on turning out, and far heavier animals towards the end of the grazing season. The amount of grazing necessary for the young calf is quite small, based purely on nutritional requirements; a stocking rate of 20–30 per acre is quite feasible for a short period after turn-out. At this stage other husbandry factors such as access to shelter or room to avoid huddling in adverse weather are more important. Once completely settled down an overall stocking rate of 3–5 calves per

acre has been the order on both farms. At this rate, grass production is well beyond their requirements during the first part of the grazing season. The practice has been to put up over half the area for spring silage and this area becomes available as fresh aftermath grazing from July onwards. Thus, in addition to grazing, the area contributes some silage for the following winter.

Liveweight Production

With spring born calves turned out at approximately 6 weeks of age, that is by the 1st April, and grazed at 4 calves per acre with a daily gain of $1\frac{1}{2}$ lb, a liveweight gain per acre of a 1,000 lb during the grazing season up to mid-October is produced. In addition there would be the silage contribution of at least 3 tons per acre overall. This would be quite a modest performance and would in fact be disappointing, but it is sufficient to illustrate the part grass can play in rearing spring born calves. Output of liveweight at the two farms and also at Drayton Experimental Husbandry Farm, where rearing at grass has been practised now for a number of years, has been well above that quoted above.

Earlier Purchasing

In recent years at Liscombe, calves have been purchased in January and February. This has meant that they are a little older on turn-out but it has always been possible to get them out before the end of March. The practice is to harden off by turning out into a yard for 2–3 hours for a few days, and to attempt to catch a mild spell. Calves have always been turned out abruptly with no artificial shelter although it must be admitted that the West country type of hedge bank provides excellent protection from the elements. Advantages of earlier purchasing are that there is a longer grazing season in the calf stage and calves come off grass at heavier weights of between $4\frac{1}{2}$–$5\frac{3}{4}$ cwt.

Advantages in Rearing at Grass

Up to 3 months of age there is very little reduction in concentrate requirement. From then on until the end of the grazing season it is possible to save 5–6 cwt concentrates and a similar amount of hay compared with indoor rearing. This in financial terms would amount to between £10 and £12 per calf against which must be put the cost of grazing. Less time is spent in looking after the calves as there is no bedding or mucking out of pens to be done. If a small rate of concentrate feeding is continued through the summer this takes up very little time in addition to the daily inspection of the calves.

If paddocks are divided by means of an electric fence, then some training is advisable beforehand. The usual practice has been to run a single strand with the posts sloping at 45 deg to commence with, raising them gradually to the vertical position as the calves grow. Health problems generally have been few, especially respiratory troubles which seem to be on the increase under indoor conditions. Management factors which bear re-emphasizing

include the need to provide a sequence of leafy herbage in adequate quantity throughout the whole grazing season. If, because of some limiting factor such as drought conditions, grass availability is restricted, then some supplementary feeding is desirable to avoid a period of standstill. A close watch against parasitic infection must be kept, and if action is necessary, treatment should be without delay. Like all systems of animal husbandry, good stockmanship is essential.

ONCE-A-DAY FEEDING OF MILK SUBSTITUTE TO CALVES

D. A. Perks,* *Gleadthorpe Experimental Husbandry Farm*

Over four hundred calves have now been reared on six Experimental Husbandry Farms using the once-a-day feeding of milk substitute technique. Results have on the whole been very encouraging with healthy calves of satisfactory weight being produced at twelve weeks of age.

At Boxworth, Bridget's and Trawscoed, Friesian heifer calves from their own dairy herds have been reared. Bridget's now rear most of their heifer replacements on once-a-day feeding from four days old using cold water at tap temperature, usually 40° to 50°F. This has proved a satisfactory and reliable technique, although Friesian × Ayrshire calves have proved less tractable than pure Friesians and usually take longer to learn to drink cold fluid. Trawscoed have reared calves satisfactorily on once-a-day feeding with 8 per cent fat milk substitute fed warm. Boxworth compared cold milk substitute fed once or twice a day and although there were no digestive upsets or feed refusals, the calves fed twice a day had better liveweight gains.

Of the beef E.H.F.s, Gleadthorpe and High Mowthorpe have compared the once- and twice-a-day feeding of warm milk substitute to Friesian and Hereford × Friesian bull calves purchased at 10 to 14 days old. Equally good calves have been reared on both systems and Gleadthorpe has now adopted once-a-day feeding as standard practice where experimental demands do not dictate otherwise. Liscombe has compared once-a-day feeding with normal twice-a-day feeding and $5\frac{1}{2}$-day feeding, all using warm milk substitute, and with *ad libitum* cold milk feeding. With both summer-born Devon × Friesian heifers and winter-born Hereford × Friesian bull calves, all four systems produced acceptable beef calves at 12 weeks of age.

In general in all these studies no advantage has been found for delaying changeover to once-a-day feeding. At Boxworth and Bridget's this has been done at 4 days straight off colostrum, and at other farms bought-in calves have been successfully started straight onto once-a-day feeding. Early weaning concentrates and hay have always been freely available, and a continuous supply of fresh clean water is essential as calves drink greater quantities of water when only offered milk substitute once a day. They also eat significant amounts of dry food earlier and can thus be weaned slightly sooner in many cases.

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* Now at N.A.A.S. Headquarters.

The health record of calves fed once a day, particularly in respect of digestive upsets, has not been noticeably inferior to that of twice-a-day fed calves. However, it would be wise to assume that when digestive upsets do occur, calves fed once a day are likely to be under greater stress than those fed lesser amounts more frequently, so that early diagnosis and treatment will be at a premium.

Trials have recently been initiated which will be carried out at several centres aimed at further simplification of calf rearing routines. In these, once-a-day feeding of cold, low fat content milk substitute to various types of calves, who will be weaned as soon as they are consistently eating 1 lb per day of concentrates, is to be compared against various other systems already successfully in use. The aim is to identify a simple system which can be relied upon to rear healthy calves cheaply, both in terms of labour requirements and feed costs.

DATE OF WEANING AND WEANING MANAGEMENT OF LAMBS

M. Hastings and C. F. R. Slade, *Liscombe Experimental Husbandry Farm*

Experiments at Liscombe comparing different systems of grazing ewes with lambs at high stocking rates indicated little difference between grazing systems. However, one consistent observation was that growth of lambs was very good for the first ten–twelve weeks of the lamb's life, at about $\frac{1}{2}$ lb per day, but growth then dropped quite markedly to about half this rate. This reduction in lamb growth rate has been commonly observed commercially and commented on by a number of other experimental workers.

The practical consequences of a decline in growth rate are fairly obvious. The number of fat lambs produced will fall and the proportion of store lambs increase. It also means that the number of poor store lambs left unsold at the end of the season is increased. This both reduces the financial return and creates greater management problems.

There does not seem to be one obvious cause for this drop in growth rate, but it could be due to one or more factors such as worm infection, increasing competition between lamb and ewe for grass, increasing unpalatability of heavily stocked pasture, a fall in pasture quality, or even a change in the botanical composition of the pasture.

To counter these possible inhibiting factors an attempt was made to wean lambs earlier than the traditional sixteen to 20 weeks. This was to see whether removal from the ewe and grazing on clean pasture enabled lambs to avoid the decline in growth rate.

This approach was suggested by experimental work which has established that the rumen of a lamb begins to function from two weeks of age and that by eight weeks the rumen has expanded to normal adult proportions. Therefore, lambs should be capable of fending for themselves from an early age, if necessary.

Scotch half-bred ewes with twin lambs were used for the experiment which ran for three years. The ewes and lambs were stocked at six ewes and twelve lambs to the acre. Lambs were weaned at eight, twelve or sixteen

weeks and folded on Italian ryegrass that had not previously carried sheep. One lamb from each pair of twins was wormed at weaning time, since it was possible that a worm burden was limiting growth. Half the lambs weaned at sixteen weeks were fed concentrates for the month before weaning, to see if this improved the growth rate.

In each year the lambs weaned at twelve weeks grew better than lambs weaned at any other age. The mean liveweight at twenty weeks, of the twelve-week weaned lambs was 79 lb. This gave an average liveweight gain of $\frac{1}{2}$ lb per day from birth to twenty weeks of age. However, the liveweight gain was still higher from birth to twelve weeks than from twelve to twenty weeks.

Lambs weaned at eight weeks did not grow quite as fast after weaning as those weaned at twelve weeks, whilst those weaned at sixteen weeks showed the familiar decline in growth rate from twelve weeks onwards. In only one year out of the three was there a significant response from feeding concentrates during the month before weaning at the sixteenth week, and this was insufficient to pay for the cost of the concentrates consumed. No differences were apparent between those lambs dosed with phenothiazine and the untreated lambs. This lack of response to drenching was explained by the results of sample worm-egg counts. These showed that nematodirus eggs were only present in isolated cases, and in small numbers. The incidence of strongyle ova increased slightly over the period of the trial but not to a significant degree. The mean twenty-week weights of the lambs were:

Weaned at 8 weeks	74 lb
Weaned at 12 weeks	79 lb
Weaned at 16 weeks	69 lb
With concentrate	73 lb

Thus, under Liscombe conditions where lambs were moved to fresh pasture after weaning, twelve-week weaning appeared to be optimum. However, it was still uncertain what was causing the depression in growth rate when lambs were not weaned at twelve weeks. There was no apparent shortage of grass, and although there was a slight build-up of nematodirus infestation, dosing appeared to have little beneficial effect on growth. A practical point to be considered is the difficulty in providing fresh aftermath for 12-week weaned lambs, for these are only generally available on farms where silage making is practised. Lambing would have to be delayed until April to make use of hay aftermaths. Thus, a further experiment was conducted to determine the importance of clean aftermath for the weaned lamb and the value of a more powerful anthelmintic, thiabendazole.

Lambs were weaned at either twelve or sixteen weeks under one of the following systems of management:

12-week weaning, undosed,	then kept on same pasture
12-week weaning, undosed,	then moved to clean pasture
12 week weaning, dosed,	then kept on same pasture
12-week weaning, dosed,	then moved to clean pasture
16-week weaning, dosed	then kept on same pasture
16-week weaning, dosed,	then moved to clean pasture.

Thus a comparision was obtained of the optimum age of weaning under intensive rotational grazing systems when lambs were either weaned onto

fresh pasture or stayed on the intensively grazed area. Also the value of dosing at weaning, under these two systems was observed.

Equal numbers of Welsh half-bred and Scotch half-bred ewes suckling twin lambs, were employed on the trial at a stocking rate of eight ewes and sixteen lambs per acre. The lambs were sold at twenty weeks as store lambs at the following average weights:

12-week wean, undosed, same pasture	60·0 lb
12-week wean, undosed, clean pasture	74·8 lb
12-week wean, dosed, same pasture	61·3 lb
12-week wean, dosed, clean pasture	75·0 lb
16-week wean, dosed, same pasture	64·0 lb
16-week wean, dosed, clean pasture	69·5 lb

The major factor affecting lamb growth from twelve weeks onwards was the provision of clean pasture. Under the clean pasture system, dosing proved of no benefit, but where the same pasture was used as weaning ground, then dosing was of slight benefit.

A study of the lamb growth rate during the twelve to sixteen and sixteen to twenty week periods indicated that twelve-week weaning was of benefit when clean land was available. If clean land was not used, then twelve-week weaning was more harmful than keeping the ewes with the lambs until sixteen weeks.

Between sixteen and twenty weeks, all groups which had clean pasture continued to grow at a similar rate and maintained good condition. Those groups remaining on the same pasture all lost weight and this was most marked in the twelve-week weaned, undosed group, where in fact one lamb died as a result of a heavy worm burden.

Within each treatment group of lambs it was significant that both early and late-born lambs gained at a similar rate when clean land was used as the weaning pasture. However, when left on the same ground the later born lambs were markedly poorer than earlier born lambs, perhaps an indication of a progressive build-up of worm infection in some lambs.

The results of these trials indicate that the decline in growth rate of intensively stocked lambs can be countered by twelve-week weaning onto previously sheep-free aftermaths. If clean land is not available then this earlier weaning will be detrimental to the lambs' performance. Nevertheless, where weaning has to be delayed to the more traditional sixteen weeks of age, clean aftermaths are again essential if reasonable lamb performance is to be achieved.

FODDER CROPS FOR LAMB FATTENING

M. Appleton, *High Mowthorpe Experimental Husbandry Farm*

Folding lambs on roots has been a common feature of Wold farming for many years. Fodder roots provide an ideal opportunity for cleaning land of weeds before sowing in May or June, but must produce a reasonable margin of profit if they are to be justified. Swedes and hardy kales are suitable crops for feeding over winter but other faster-growing crops are more suitable for finishing store lambs quickly before Christmas.

Trials have been conducted at High Mowthorpe with Suffolk × Scottish half-bred lambs since 1962, to look at various alternative crops for the fattening of store lambs in autumn.

The investigations in the three years 1962–64 showed that after weaning in August, lambs grew as well on grass and stubbles as on specially grown crops of rape and Italian ryegrass. Forward lambs went fat in September and the remaining lambs were folded on crops of kale and soft turnips, going fat in January. The best level of concentrate supplementation appeared to be about ½ lb rolled barley per head per day. During adverse weather conditions a higher level of supplementation was warranted.

Areas of mustard, fodder radish, giant rape and kale were sown broadcast in June of 1964 and 1965. Lambs grazed these crops during August and September. Those on giant rape gave the best performance in both years, with liveweight gains of ¼ to ½ lb per lamb per day. Kale gave a rather lower performance. The lambs on fodder radish and mustard lost weight, even though both crops provided a large bulk of feed. Fodder radish grew rapidly to maturity and then declined in palatability and digestibility after flowering.

In 1966 and 1967 a quick-growing Dutch turnip variety, Ponda, was introduced into the trials. Half an acre was grown together with a similar area of giant rape and a mixture of Ponda and giant rape. Seed was broadcast in June at 7 lb per acre of Ponda, 6 lb per acre of giant rape, and 6 lb Ponda plus 2 lb giant rape per acre in the mixed crop. The areas were grazed at about 40–60 lambs per acre from September to mid-November.

The performance of the lambs on all treatments was satisfactory and weight gains were between ¼ and ½ lb per lamb per day.

Performance of lambs on fodder crops

	1966		1967		
	L.W.G./ac lb	Lamb grazing days/ac	L.W.G./ac lb	Lamb grazing days/ac	D.M. yield of crop tons/ac
Ponda turnip	318	556	342	931	2·3
Giant rape	180	600	312	980	1·6
Ponda/rape	281	638	358	942	2·8

Ponda turnip alone and the Ponda and rape mixture produced higher liveweight gains per acre than the giant rape alone in both years, and this result was confirmed by an estimate of the dry matter yield of the crops made in 1967.

The Ponda turnip produced small roots and a large amount of top at the seed rate used. The possibility of increasing dry matter production by reducing seed rate and thus increasing root size was investigated in 1968. Areas of two-and-a-half acres were drilled with either 2 lb seed per acre or 4 lb seed per acre in June. Lambs stocked at 60 per acre grazed these areas during November and were supplemented with ½ lb rolled barley per lamb per day.

A summary of the results is given in the following table:

Seed rate lb/ac	L.W.G./ac lb	Lamb grazing days/ac	D.M. yield of crop, tons/ac
2	838	1169	3·1
4	881	1233	3·1

The lambs gained weight at an average of 0·7 lb per day.

The good liveweight gains achieved were due to some extent to the supplementary feed but both seed rates produced a high liveweight gain per acre. This variety of turnip has given good results in all three seasons at High Mowthorpe as it provides a good yield of green fodder and maintains its feeding quality for a reasonably long period. It will not withstand hard frosts, however.

Further experimental work is planned with Ponda turnip to investigate the effect of date of sowing and its suitability for early finishing of store lambs weaned in July.

WINTERING OF EWES ON FOLDED ROOTS OR SILAGE

K. C. Morrisson, *High Mowthorpe Experimental Husbandry Farm*

The long-term effects on the performance of ewes wintered each year on either folded swedes or grass silage were observed at High Mowthorpe over a period of seven years. From 1958 to 1961, 218 Scottish halfbred ewe lambs were selected on weight and previous history, paired and allocated to the treatment groups, 109 to each group, when 9 to 10 months old. They remained on the experiment throughout their productive lives.

Treatment periods extended from January to April each year, with the two groups managed as one flock throughout the rest of the year. During the treatment period the root group were close folded on swedes, with a lie-back on to grass. Roots were carted to them at grass after lambing commenced. In severe winter weather hay was fed. The silage group received good quality grass silage fed in racks, either on grass or on cereal stubbles. Daily consumption of silage averaged about 10 lb per ewe.

Both groups received equal quantities of supplementary concentrates prior to lambing.

The relative performance of the two groups varied between seasons, due to weather affecting performance on roots or to silage quality, but, averaged over the years, the method of wintering had little effect on the number of lambs born and reared per ewe. Live births per ewe tupped averaged 1·77 for the root-fed ewes and 1·76 for those fed on silage. There was little effect on the growth rate of lambs, or on fleece weights of the ewes.

The major differential effect of the treatments was that dental deterioration was more rapid in the root-fed ewes. These had to be culled out earlier

because of broken mouths. The result was that each root-fed ewe had on average a productive life of 3·7 lamb crops whilst those wintered on silage produced 4·1 lamb crops before culling or death. The effect of this in practice would be a reduction in replacement costs. The lower depreciation of silage-fed ewes would amount to about 2s. per ewe per year.

The higher replacement rate required in the root-fed flock would mean a slightly higher proportion of young ewes in the flock. The possible reduction in lambing percentage of a younger flock would probably be offset by the decline in prolificacy which would occur amongst the older ewes in the silage flock.

These factors are not of sufficient economic importance to justify a change from a successful root feeding system to silage. The change from roots to silage is more likely to be influenced by the fact that silage production makes for a better integrated system of grassland management. In particular, it affords an opportunity to reduce the grazing pressure at a critical time of year, when lambs can be turned on to clean silage aftermaths.

Wintering ewes on roots does nothing to reduce summer grazing requirements and adequate areas of aftermath grazing are just as necessary as when silage is the main winter feed. The provision of adequate aftermaths would result in there being a surplus of conserved grass where ewes are wintered on roots. It is calculated that this surplus would amount to around 4 tons of hay per 100 ewes.

The silage feeding system resulted in more efficient utilization of land and increased the gross margin per ewe by 5s. and the gross margin per acre by 20s.

UREA FOR DAIRY CATTLE

M. J. Strickland*, *Great House Experimental Husbandry Farm* and
G. Alderman, *Regional Nutrition Chemist, N.A.A.S. South Eastern Region*

One of the unusual properties of the microbes in the rumen of a cow is their ability to make protein from ammonia. Most of the ammonia comes from the breakdown of food protein, but some of it comes from urea secreted in the saliva. Urea is the form in which waste nitrogen is excreted in the urine, but it is also made synthetically in commercial chemical plants.

Since urea contains 46 per cent nitrogen and can be converted into six times it own weight of protein whilst only costing £40 per ton, it would seem to offer opportunities for reducing the cost of the protein part of dairy concentrates.

Synthetic urea, $CO(NH_2)_2$, is a white crystalline powder which dissolves easily in water. It can be mixed in concentrates as a dry powder at 1 to 2 per cent of the ration, but higher levels can cause symptoms of toxicity and even death, due to excessive ammonia formation in the rumen. A study of the acceptability, safety and efficacy of urea as a substitute for protein in dairy cow concentrates appeared worthwhile as a way of reducing costs in milk production.

Experiments were started in 1965 at Bridget's, Boxworth, Great House and Trawscoed Experimental Husbandry Farms. The first exploratory trial

* Now at Boxworth E.H.F.

at Great House was a simple one to find if there were any harmful effects in feeding a small quantity of urea in a home mix. Two rations were compared, a normal dairy concentrate containing 14 per cent protein, and the same ration but with 11 lb urea mixed with 1 cwt barley added in place of 1 cwt soya bean meal in a one ton mix, equivalent to $\frac{1}{2}$ per cent urea. On this basis the crude protein (N% × 6·25) content of the two rations was the same. The results indicated no harmful effects or difficulties in feeding the urea when it was premixed with the barley before normal mixing with the remainder of the ration. Milk yields from the cows fed the urea concentrate were only slightly lower than from those fed the normal dairy concentrate, but the urea-containing concentrate cost 17 shillings per ton less.

In subsequent trials at Trawscoed, Boxworth and Bridget's, the amount of urea was increased to 1 per cent of the ration or 22 lb per ton. This amount of urea together with 2 cwt barley replaced 2 cwt soya bean meal or an equivalent amount of other vegetable protein. Typical rations compared were as follows:

	Type of concentrate	
	Normal	Urea
Barley	15½ cwt	17½ cwt
Dec. ground nut	1½ cwt	1½ cwt
Soya bean meal	2 cwt	—
Fish meal	½ cwt	½ cwt
Minerals and vitamins	40 lb	40 lb
Urea	—	22 lb

The normal dairy concentrate mix varied slightly at each farm but in each comparision with a urea ration, the normal concentrate was formulated to supply the same amount of energy and crude protein. Both concentrates were fed to the cows at 4 lb per gallon of milk produced, together with hay or silage for maintenance. The results of these experiments showed that there were no harmful effects from the higher rate of inclusion of urea, and milk yields and milk quality were the same as for the normal dairy concentrates.

The rate of inclusion was increased further to 1½ per cent, or 33 lb per ton in trials at Great House and Trawscoed in the winters 1966–67 and 1967–68. At this higher level urea replaced all the added vegetable protein in the ration so that the two rations contained the following ingredients:

	Type of concentrate	
	Normal	Urea
Barley	17½ cwt	19½ cwt
Dec. ground nut	1 cwt	—
Soya bean meal	1 cwt	—
Minerals and vitamins	56 lb	56 lb
Urea	—	33 lb

Hay or silage of about 11 per cent crude protein in the dry matter was fed for maintenance.

The results of the Trawscoed experiment showed no ill effects from urea feeding but some high-yielding cows would not eat all the urea concentrate offered. Milk yields were only slightly lower than from the conventionally fed group. At Great House however, milk yields were about $1\frac{1}{4}$ gallons per week less with the urea fed cows.

It is sometimes argued that urea is not used efficiently by the cow, but that this is not evident with much dairy cow feeding because there is already sufficient protein provided in the basal roughage of hay or silage. In order to test this, a third treatment comparision was added in the last Great House and Trawscoed experiments when barley only was fed (with minerals and vitamins) as the concentrate. This ration naturally had a very low protein content and all the rations were fed with a hay of low protein content. At both farms, cows fed the normal dairy concentrates gave more milk than those fed either the urea or barley only concentrate. There was little difference between the barley and urea rations in their effect on milk yields, but cows lost slightly more body weight with the barley only feeding.

The moderate performance of the urea rations may have been due to a number of factors, including the effect of home mixing. Samples taken from one mix showed a range in urea content from 0·5 to 2·2 per cent. Possibly, the urea was not utilized properly and urine samples taken from cows at Great House showed that urine from cows fed urea concentrates had a higher urea content than that from cows fed other rations.

Urea has also been used at the 1 per cent level in a straw balancer concentrate mixture used in experiments at Bridget's and Boxworth E.H.F.s.

Straw Balancer Concentrate

Barley	17 cwt
Dec. ground nut	$2\frac{1}{2}$ cwt
Urea	22 lb
Minerals	$\frac{1}{2}$ cwt
Vitamins	7 lb

This mixture had a calculated crude protein content of 14 per cent. 6 lb were fed with 10–12 lb barley straw for maintenance, and 4 lb fed for each gallon of milk produced. Over a period of 10 weeks at Bridget's E.H.F., the cows fed this balancer averaged 3·9 gallons with satisfactory milk quality. No control group without urea was included, but cows fed tower silage and barley yielded an average of 3·6 gallons over the same period.

No problems were experienced in acceptability of the concentrate containing urea, nor were there any difficulties which could have been attributed to inadequate mixing of the urea. The straw balancer concentrate was costed at £26 12s. 0d. per ton.

The inclusion of urea at the 1 per cent level in concentrates which are carefully home mixed may, therefore, have a place in helping to reduce feeding costs, but the use of higher levels thus eliminating all vegetable protein, may reduce milk yield and offset the expected cost savings. When

urea is to be used it is probably best to restrict it to a maximum of 1 per cent of the ration, and to include a small proportion of vegetable protein such as soya or ground nut in addition.

LEAST-COST RATIONS FOR PIGS

A. G. Chamberlain, *University College of North Wales*

Least-cost rations are those that provide the known essential nutrients at levels reckoned to meet requirement at the lowest possible price per ton. When a large number of ingredients are available for incorporation into the ration, the task of calculating the least-cost combination is much simplified by the use of a computer. The proportions and types of feedstuffs used to make the ration are altered by changes in their cost, and in some circumstances the composition of the ration may change dramatically. A farmer wishing to reduce feeding costs by using least-cost formulations must be prepared to change the meal given to his pigs at short notice. In order to check the effects of frequent changes of diet on pig performance, experiments were carried out at Great House and Trawscoed Experimental Husbandry Farms.

Five meals were compounded from commercially available ingredients. They each had approximately 16·4 lb of crude protein per 70 lb Total Digestible Nutrients (T.D.N.) and 0·88 lb lysine per 70 lb T.D.N.; their composition is shown in the table. The daily T.D.N. allowances of pigs were governed by a scale, so that for each treatment, pigs of the same weight received similar daily T.D.N., crude protein and lysine allowances irrespective of the diet they were given.

Percentage composition of the rations

	Control				
	Ration IA Barley and weatings	Ration IB Barley, soya and fish meal	Ration II Maize	Ration III Oats	Ration IV Wheat
Cereal	75 (barley)	84 (barley)	76 (maize)	92 (oats)	85 (wheat)
Weatings	15				
Soya bean meal		11	20		
White fish meal	10	5	4	8	
Herring meal					10
Meat meal					5
Minerals and vitamins	+	+	+	+	+

At Great House, groups of eight Large White pigs were group-fed twice daily in troughs, two pints of water being added to a pound of meal, whilst at Trawscoed, groups of ten pigs of the same breed were floor-fed twice daily. At both farms water bowls were available. The pigs at Great House

weighed about 50 lb and at Trawscoed, about 70 lb at the start of the trial; pigs were slaughtered at 200 lb.

At both centres one barley based ration was chosen to serve as a control. The performance of pigs fed this meal continuously was compared with others which had their diets interchanged between the control and the other meals at 2 or 3 week intervals.

There was no evidence of any digestive disorder caused by the ration changes, and the pigs never refused to eat their diets. At Trawscoed, three pigs died; two of them had been on the control treatment and the third died suddenly at nearly 160 lb weight. At Great House, a pig suffering from septic arthritis was slaughtered.

The growth rates and carcass measurements of pigs on all treatments at both farms were remarkably consistent. Daily liveweight gains were between 1·22 and 1·38 lb per head and the difference between treatments within any of the three experiments performed did not exceed 0·11 lb. Differences in carcass measurements were also small and it is clear that the regular ration changes had little or no effect on performance.

CAGE SIZE AND STOCKING FOR LAYING HENS

P. N. Harvey,* *Gleadthorpe Experimental Husbandry farm*

It is well known that the size of a group of hens influences the social behaviour of the group and the incidence of vices. As the group becomes larger there is a risk of increased 'social stress'. Bullying, particularly of birds low in the peck order may result in reduced production and higher mortality.

An example of how this situation can affect performance is to be found in the decline in popularity of the large mesh-floored house. Although this type of house had the advantage of low capital cost, the system proved disappointing in practice because the social stresses set up within the large flocks commonly resulted in lowered production, premature moulting and higher mortality. Cage batteries cost more per bird housed but this is justified because the system gives good results without demanding such a high standard of management, and because bullying and feather pecking are less common.

Cages vary in size and the number of birds that can be accommodated in them. The capital cost of housing is naturally higher where the birds occupy small cages designed to hold one or two birds than where the cage size and number housed per cage are larger. The question therefore arises, how many birds can be housed in a multi-bird cage before the increasing size of the social group begins to affect flock performance as it did in the open mesh-floored house?

The aim of an investigation carried out for four years at Gleadthorpe E.H.F. was to answer this question. Six types of cage were compared, namely 16 × 18 in., 16 × 36 in., 32 × 18 in., 32 × 36 in., 32 × 54 in., and 32 × 72 in. In each type of cage pullets were stocked either at $\frac{2}{3}$ sq. ft per bird or $\frac{1}{2}$ sq. ft per bird. This was equivalent to three or four birds in the smallest

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Now at Boxworth E.H.F.

cage, and up to 24 or 36 birds in the largest one, with corresponding numbers of birds in the intermediate sized cages. Each of these combinations of stocking rate and cage size was conducted using both a light strain and light/heavy strain of bird. Food trough size was adjusted to provide a uniform trough length per bird of 4 inches. In the first two years the birds drank from troughs, in the second two years nipple drinkers were provided. The birds were not debeaked but were kept in a low light intensity provided by 25 watt bulbs approximately 8 feet apart. Casualties were replaced by spare birds which had been kept in the same type of cage as the ones in which the casualties occurred.

Including reserves, the total number of hens in the experiment was 2,259 or an average of about 180 birds per treatment. Egg production and mortality was recorded for each cage throughout the laying period and food consumption, egg weights and grades were recorded from a sample group of cages representing each stocking density and type of bird. The sample group at any particular time was equal to one-sixth of the total number of birds in the experiment and a different sample was recorded in each four-week period.

Egg Production

On a hen-day basis, egg production averaged 4·5 per cent lower in the densely stocked cages compared with that obtained from the birds that were stocked moderately. The adverse effect of the higher density was more marked in the case of the light/heavy strain than the light strain. The respective differences of 5·4 per cent and 3·3 per cent production strongly indicate the existence of a genotype environment interaction. In addition there is an indication in the performance of both strains that the reduced output, which occurs as cage size and, therefore, the numbers of birds per cage increases, tends to level off more quickly at the lower density than at the higher density. Taking the 3-year average hen-day egg production, the performance of flocks consisting of 24 birds at the moderate density was very similar to the performance of flocks made up of 12 birds. By contrast, at the higher density there is an indication that a levelling off in performance does not occur until the somewhat lower levels reached with flocks of 27 and 36 birds. Other evidence (N.A.A.S. unpublished) suggests that the two strains involved in this experiment are capable of sustaining production as numbers of birds per cage are increased rather better than some other commercially available strains.

Food Consumption

Among the cages of different sizes and combining the results at the two densities, the food consumption was generally fairly uniform with individuals of the light/heavy strain averaging about 0·2 oz per day more than those of the light strain. At the higher density, food consumption per bird in both strains averaged 0·2 oz per day less than at the lower density. Both these differences were significant.

Egg Quality

Neither size of cage or stocking density influenced the relative proportions of eggs in the different size grades. The number of cracks, however, was 25 per cent higher in the larger cages and there was not much difference between the two rates of stocking in this respect.

Mortality

Although there was considerable variation in the mortality levels among the treatments, at the moderate stocking density the results did not indicate mortality to be higher in the larger cages than in the smaller ones. In fact, the average mortality in the two largest sized cage types over the three years was less than in the smallest cages. With dense stocking, however, there was a fairly consistent trend to higher mortality with increasing size. Over the 3 years the birds housed at 36 per cage showed a mortality level very much higher (12·27 per cent overall mortality) than those housed at 4 birds per cage (7·53 per cent mortality). There was also a general tendency for mortality in the light strain to be lower than that in the light/heavy strain for all cage size groups. This was particularly marked at the moderate stocking density.

The vast majority of these deaths were due to prolapse or cannibalism. A problem in recording resulted from the fact that the only way of replacing dead birds on a particular treatment was to introduce into the depleted group a replacement from spare birds housed in a cage of the same size as where the casualty had occurred. Bullying of the newcomer sometimes resulted in its death and consequently there was a tendency once a death had occurred in a cage for further deaths to be recorded in the same cage. Nevertheless, the conclusion that mortality was higher in the larger cages is supported by observation throughout the experiment. It was obvious that the birds in the big cages were more restless and nervous than in the smaller groups and reacted much more violently to disturbance, for example, when a stranger walked through the house. This emphasizes the greater social stress on the birds in the larger units and hence is a reasonable explanation of the higher number of deaths which were recorded.

Conclusions

When housing birds at the same density there is very little difference in cage cost between groups of three or four birds housed together and groups made up of larger numbers. The saving in cage divisions is negligible when written off over a period of years. Thus the results of this experiment substantiate the view that small groups of birds give better economic performance than do larger groups. However, the results also indicate that the decline in performance between three and six birds per cage when housed at the moderate density is not as great as occurs when the number per group is increased beyond six. This was particularly true of the light/heavy strain where performance was much the same for the first three cage sizes.

When assessing the space allowance per bird, the overall trend for a higher output of eggs at the lower density suggests this as being a preferable

treatment. Capital costs per bird are, however, a factor in this case and should be considered. With the light/heavy strain, the difference of 5·4 per cent is equivalent to about 13 eggs which would be worth, say, 2s. 9d. If the feed saving of about 8d. per bird at the higher density is taken into consideration, the actual loss is of the order of 2s. 1d. per bird.

With the light strain, the reduced performance amounts to about 8 eggs and similar calculations suggest a loss of 1s. per bird. Unfortunately it is not possible to apply such a straightforward interpretation to farm situations because of a number of other factors that also affect profitability. The actual density appropriate to a given farm situation depends on the actual production levels that would be expected on that farm, the egg price structure and the overhead costs, which, of course, include capital investment.

The complexity of the problem is illustrated if the two main sets of relationships are considered. There are those relating to performance levels and those concerned with margins. In general, enterprises where performances and margins are low should not risk a reduced level of output per bird, but where the margin between cost and return is high the increase in output achieved at the expense of output per bird may be justified. The other major factor, which may be at variance with the first, is that when egg prices are high returns may be improved by increasing yield per bird, even though the capital investment and other costs per bird may also be increased. When egg prices are low the converse situation tends to operate and it may be more profitable to accept lower yield per bird but increased return on capital investments.

Careful judgment is required in applying the results of this experiment to farm situations. Although the general trends in performance may be relevant to many farms, and N.A.A.S. survey results (unpublished) would tend to substantiate this view, a decision in relation to any one farm must take into account performance levels, the strain of bird and the cost/price structure that exists for that farm.

EARLY COMPARISONS OF TWO GLASSHOUSE DESIGNS

F. G. Smith, *Stockbridge House Experimental Horticulture Station*

In 1966 building of a multifactorial glasshouse unit started at Stockbridge House E.H.S. The unit consists of four glasshouses each 240 ft long by 42 ft wide. Each of these houses is divided into six compartments which have individual heating and ventilation control to enable studies on glasshouse environment to be conducted. The structures themselves were completed in the spring of 1967 but heating and ventilation control was not fully operative until twelve months later. In each of the houses the four central sections, having no outside gables, are regarded as experimental compartments, and the outside sections act both as guards to the experimental compartments and as propagating units.

The houses themselves are of two types, four-span Venlo houses and single clear span houses; both types are orientated east-west and both have an 8 -ft eaves height. The eaves height was fixed so that low angle winter

sunshine passing through the south wall of the houses could reach the whole of the cropping area. Such sunshine passes through the south walls at a favourable angle of incidence to the glass, thereby permitting a high level of light transmission. Both types of house are of metal construction with aluminium glazing bars and Dutch light width glass, although in the case of the single span houses the full length of the Dutch light glass was not used as it was not considered that the glazing clips could hold it securely; each sheet of glass was therefore cut into three. The area of glass in the roof of both types of house is approximately the same although there is naturally a greater area in the gables of the single span houses than the multispan houses.

The single span houses are built with an uneven span, the south facing slope of the roof being inclined at an angle of 40 deg to the horizontal whereas the northern roof is at the traditional 26 deg to the horizontal. The reason for increasing the slope of the south facing roof was to improve the transmission of direct sunshine reaching the floor of the house.

The first crop to be grown in these houses was tomatoes. These were planted in May 1967 and grown without heat. The tomatoes were followed by lettuce crops in the autumn and winter of 1967–68, also grown without heat or with only improvised heating sufficient to keep out the frost.

Following the construction of these houses a certain amount of levelling of the soil was necessary to ensure the same level in each compartment. This was done as far as possible by grading the subsoil and replacing above it a uniform layer of topsoil. It was inevitable, however, that some soil difference existed between compartments and these early crops were designed to enable such differences to be detected. The soil, which was basically a poor sand, received heavy dressings of organic matter with the object of ironing out differences as quickly as possible.

It was also desired to obtain information of positional effects on the crop which may be caused by the superstructures, although it was appreciated that these might be modified by the effects of the heating system after it had been installed.

In addition to cropping the houses, some preliminary measurements were made during 1967 on the amount of light entering these houses. Light measurements were made simultaneously in comparable positions in sections of each of the house types, and these were compared with an outside reading of light value.

Summary light readings, 1967

Month	Mean per cent of radiation entering house		Difference in favour of single span
	Single span	*Venlo*	
Jan	65·06	63·23	+1·83
Feb	58·98	57·56	+1·42
Mar	57·28	54·13	+3·15
Sep	58·36	53·06	+5·30*
Oct	61·17	59·49	+1·68
Nov	52·68	51·81	+0·87
Dec	58·58	52·26	+6·32*

*Significant at the 5 per cent level.

These light readings were made round about mid-day when interference from the partitions in the houses is likely to be at a minimum level. The single span houses are approximately twice the height of the multispan Venlo houses at the ridge and consequently shading from the partitions within each section is greater in the single span houses. The effect of partitioning the houses to provide experimental compartments, therefore, gives an unfavourable bias to the single span houses.

In addition to these differences in light transmission which were of a kind anticipated from theoretical calculations based on the designs of the houses, there is also evidence of greater humidity in the multispan houses than in the single span houses. This is confirmed by the greater number of air changes which take place in the single span houses as compared with the Venlos. It was clear from observation that the Venlo houses were in the first instance very much better sealed than the single span houses. In the Venlo houses, for example, each sheet of glass is bedded on all four sides to either a mastic or plastic surface. In the case of the single span houses there was a large number of overlaps through which air can pass when the roof is dry and initially the doors and partitions were not well sealed. Following the sealing of doors and windows the single span houses have been made very much more airtight, but they still allow for a greater number of air changes than the Venlo houses under unventilated conditions. CO_2 enrichment within four compartments of each house type is controlled by an infra-red gas analyzer. It has been shown that to achieve comparable levels of enrichment within the two house types a great deal more propane must be burned in the single span than in the multispan house. It has yet to be determined whether heat losses will follow the same pattern.

In growing tomato crops in these houses it soon became apparent that the tomatoes in the single span houses required more water than those in the multispan houses. The difference in water requirements was in the order of ten per cent. These differences are thought to be due (a) to the better light transmission in the single span houses, and (b) to the lower humidity in these houses resulting from the more frequent air changes.

Effect of glasshouse design on yield of tomatoes

Variety	Glasshouse type	Spacing and plant population/ac		
		12·5 in. 16,760	14·0 in. 15,020	15·75 in. 13,200
		Yield (tons/ac)		
Amberley Cross	Single span	56·3	55·6	52·9
	Multispan	51·6	49·6	49·8
Maascross	Single span	53·2	50·4	45·6
	Multispan	48·7	47·8	41·4
Eurocross B B	Single span	58·6	55·4	52·2
	Multispan	54·7	52·9	51·0

In the early experiments there have been no statistically significant differences between the lettuce crops in the two types of houses. There is

perhaps a slight trend towards earlier crops in the single span houses but the difference is not more than a few days.

With a short-term crop in 1967 and again with crops of longer duration in the spring and summer of 1968, tomatoes have cropped more heavily in the single span houses than in the Venlo houses, as is shown in the table which compares three varieties each grown at three spacings in the two house types. These differences may be explained in terms of differences in light transmission between the two houses but factors such as differences in humidity may also be involved and further work is required to isolate these from light effects.

GROWING ROOMS FOR TOMATO PROPAGATION

R. F. Jackson, *Fairfield Experimental Horticulture Station*

A preliminary trial to examine the use of growing rooms for the propagation of tomato plants was carried out at Fairfield in 1968. This resulted from the considerable interest shown by growers in the north-west in the work of Dr. P. Newton at Manchester University.

The room used was built to the specification laid down by the North Western Electricity Board. The benches each measured 8 ft long $\times$ $3\frac{1}{2}$ ft wide and were illuminated by 13 warm white 125 watt fluorescent tubes providing an illumination level of 1,000 lumens per sq. ft.

Seed of the variety Eurocross BB was sown on 27 December and growing room treatment began on 4 January when the seedlings were at the expanded cotyledon stage, with 12 hr lighting alternating with 12 hr dark at a constant temperature of 70 ± 2°F. One batch of plants spaced at 2×2 in. received illumination for 21 days and another batch spaced at 1×1 in. was illuminated for 10 days.

Following the growing room treatment, the plants were potted up and placed in the propagation houses. Half the plants from both the 21 day and 10 day treatments were given CO_2 enrichment and the other half not enriched. For comparison, plants without growing room treatment were potted up in the normal manner, and these 'standard' plants were divided into two groups, half being given CO_2 enrichment in the propagation house and the other half not enriched.

Summary of treatments

21 days lighting	+ CO_2 in the propagation house
21 days lighting	— CO_2 in the propagation house
10 days lighting	+ CO_2 in the propagation house
10 days lighting	— CO_2 in the propagation house
Standard no lighting	+ CO_2 in the propagation house
Standard no lighting	— CO_2 in the propagation house

As a result of the growing room treatment the date of anthesis was brought forward and the number of weeks spent in the propagation house was considerably reduced. Thus, the extra cost of the growing room treatment was offset by reduced cost in the propagation house.

	Date of anthesis	*No. of weeks in prop. house*
21 days lighting + CO_2 in prop.	22 Feb.	4
21 days lighting — CO_2 in prop.	25 Feb.	4½
10 days lighting + CO_2 in prop.	29 Feb.	6½
10 days lighting —CO_2 in prop.	3 March	7
Standard no lighting + CO_2 in prop.	6 March	9
Standard no lighting — CO_2 in prop.	11 March	10

Cost of growing room treatment

The costs given are based on a 3 bench room built at a cost of £400 excluding labour for erection, depreciation being taken over 10 years. The estimated period of use is 10 weeks per annum. The costs of current, labour and materials are included in addition to normal propagation costs.

21 days lighting (2 × 2 in. spacing)	4d. per plant
10 days lighting (1 × 1 in. spacing)	1d. per plant

Total variable costs

These are given as the costs incurred to bring the plant to the stage of anthesis including the growing room treatment, heating in the propagation house and CO_2 enrichment where applicable. Not included are costs common to all treatments including labour and materials used during the propagation period.

	Total variable costs per plant
21 days lighting + CO_2 in prop.	6¾d.
21 days lighting — CO_2 in prop.	6¼d.
10 days lighting + CO_2 in prop.	5¼d.
10 days lighting — CO_2 in prop.	4½d.
Standard no lighting + CO_2 in prop.	6d.
Standard no lighting — CO_2 in prop.	5d.

Time of initiation of the flower trusses

Samples of plants from each treatment were taken to determine the time of initiation of the first and second flower trusses. It has been shown by Dr. Newton that the first truss is initiated within 10 days of pricking out with the growing room treatment, in comparision with 25–30 days or even more with early sowings propagated in the normal manner.

	Date of initiation	
	1st Truss	*2nd Truss*
Growing room plants:		
10 days	15 Jan.	—
21 days	15 Jan.	22 Jan.
Standard plants:		
+ CO_2	29 Jan.	5 Feb.
− CO_2	1 Feb.	—

The samples showed that the first truss was in fact initiated after 10 lighting periods with both batches of growing room treated plants and the second truss initiated after 17 lighting periods with the 21 day treated plants.

In the 'standard' plants it is interesting to note the earlier initiation of the CO_2 enriched plants in comparision with the non-enriched.

Plants from each treatment were planted in two 150 × 15 ft aeroplane houses with CO_2 enrichment at 50 lb per acre per hour applied to all treatments until late April. Temperatures normally used at Fairfield, 13·3°C (56°F) night, 20°C (68°F) day and 23·3°C (74°F) by ventilation were employed throughout the propagation period and in the growing houses until 2 weeks after the commencement of picking. From this time the temperatures were 15·6°C (60°F) night, 18·3°C (65°F) day and 21·1°C (70°F) ventilation.

Results

	Early yield to 27 May		*Final yield to 16 Aug.*	
	lb/plant	*cash/plant*	*lb/plant*	*cash/plant*
		s. d.		s. d.
21 days + CO_2	3·9	10 8½	10·7	25 10½
21 days − CO_2	3·9	10 3½	10·6	25 6
10 days + CO_2	3·7	9 8	10·5	24 11½
10 days − CO_2	3·5	9 0½	9·8	23 4
Standard + CO_2	3·1	8 1	9·4	21 10½
Standard − CO_2	2·6	6 4½	8·7	19 8½

This preliminary experiment has shown that the growing room treatment does give a considerable boost to growth which resulted in earlier and greater total yields and consequent increase in gross returns. This applied where comparision was made with untreated plants sown on the same date. By reducing the period of propagation the saving in fuel costs and CO_2 enrichment partially or completely compensated for the costs of the lighting.

Considerable further work is required to evaluate fully this aid to propagation in addition to finding the best treatments for the duration of the lighting period and temperatures before any definite recommendations can be made.

LOAMLESS COMPOSTS

Derek R. Smith,* *Efford Experimental Horticulture Station*

The expense and variable quality of purchased loam for use in John Innes potting compost number 1 (J.I.P.1) for experimental work at Efford led first to the growing, cutting and stacking of our own turf for this purpose. But this was laborious, and did not altogether eliminate variation in compost quality. Subsequently investigations were begun on the use of composts made without loam for growing a wide variety of plants, and results obtained are described below.

Tomatoes

In 1966, five proprietary loamless composts composed of peat, or proportions of peat and sand, with base fertilizer added, were compared with J.I.P.1 for raising a July sowing of tomato Ware Cross on an irrigated sand bench, and a September sowing on the wire mesh bench normally used at Efford. With the summer sowing, the first flower stage was reached 36 days after pricking out in all six composts, and although there were differences in plant vigour between them, all the loamless mixes produced plants superior in both fresh and dry weight to those in John Innes compost. With the autumn sowing, which was hand watered, growth differences were smaller but, again, plants in all five loamless composts were as good as, or better than, those in John Innes compost.

The next step was to use a variety of suitable composts with a normal sowing for an early tomato crop, and to grow the plants on for yield comparison. With a sowing of Eurocross BB made on 11 November, 1966, two of the proprietary mixes previously used—one all peat, the other peat and sand—and a modified University of California (U.C.) compost formulated by the Glasshouse Crops Research Institute, were compared with J.I.P.1. Plants were grown by the 'blueprint' method (see Ninth Progress Report, pp. 19–22), except that, during the $6\frac{1}{2}$ weeks between pricking out and final spacing in the growing houses on 6 January, it was necessary to use a minimum thermostat setting of 14·4°C (58°F) and to omit carbon dioxide enrichment. Calculated yields, and gross market returns to the nearest £100 are given in the table.

Compost	After 4 weeks' picking (to 14 April)		After 8 weeks' picking (to 12 May)	
	Tons/acre	£/acre	Tons/acre	£/acre
J.I.P. 1	8·9	3,700	22·9	7,500
All peat	7·5	2,800	23·7	7,300
Peat and sand	7·9	3,000	22·0	6,900
G.C.R.I.	7·8	3,300	22·5	7,400

*Now at N.A.A.S. South Coast Glasshouse and Mushroom Advisory Unit, Bognor Regis.

Now that it had been shown that these loamless composts were comparable with the John Innes mixed at Efford, and had the advantages of uniformity, availability and convenience, it was decided that they were very suitable for propagating tomatoes under precise growing conditions. Indeed, the G.C.R.I. formulation has been used successfully in all respects during the past two seasons, and early growth of tomatoes has been more uniform than it was in soil-based compost, and it has been the G.C.R.I. recommendation, described below, which has been followed with all the other crops mentioned. It is made up from:

3 parts of medium or fine sphagnum peat
1 part of lime-free sand, of which 80 per cent of the particles should be between 0·5 and 0·05 mm in diameter.

To each cubic yard is added—
20 oz potassium nitrate
36 oz superphosphate (21 per cent)
10 oz ammonium nitrate (increased to 20 oz if mixed for summer use)
40 oz ground limestone
60 oz dolomitic (magnesian) limestone
10 oz fritted trace elements, FTE 253A.

It is essential that the compost is mixed thoroughly before use, preferably in a mechanical mixer.

Carnations

Rapid production of good quality cuttings was made by virus-tested carnation stock plants grown in pots of this compost set on irrigated sand benches. This has been followed by equally successful flowering of carnations treated with growth regulant and grown as pot plants.

The compost is also being used in raised troughs for a spacing trial with a commercial carnation crop. This is an attempt to improve winter flower quality, and to take advantage of the vigorous growth made by virus-tested clones by reducing propagation costs. Establishment of a planting made in early July was rapid, picking began early in January, and plants spaced at 7 in. by 8 in. were already crowded by the end of the following month. Although this was a completely new medium for growing carnations no real problems have yet arisen in their management.

Chrysanthemums

Comparisions of peat/sand compost with J.I.P.1 for year-round pot chrystanthemums began in 1968, particular interest being taken in plant quality, and the lasting properties of the flowers after the stage at which they would normally be marketed. Virus-tested Princess Anne and Bronze Princess Anne are being grown on irrigated sand benches, and on wire mesh benches with hand watering. Rapid establishment has been made in peat/sand compost, and it has given generally good results. Growth has been rather more vigorous than in J.I.P. 1 compost, resulting in slightly delayed and uneven flowering, especially on the sand benches, where water is not limiting.

In a nutrition experiment, also begun in 1968, at least three successive crops of virus-tested chrysanthemums for cutting are being grown in five types of loamless compost—all peat, 75 per cent peat:25 per cent sand, 50 per cent peat:50 per cent sand, 25 per cent peat:75 per cent sand, and all sand. All combinations of liquid fertilizer treatments to supply 100, 300 and 500 lb of nitrogen, and 200, 400 and 600 lb of potash per acre of bed, per crop, are being compared, and some initial problems with applying the fertilizer have been overcome. Establishment in the peat:sand mixtures has been very good, and although there have been growth differences between the nine liquid feeding treatments, these have not been large enough to result in failures. The first crop flowered at Christmas, 1968, and, after steam sterilization of the bed, the next crop was planted in mid-January. The longevity of flowers, following the different treatments, is being closely examined.

Zonal Pelargoniums

Year-round growth of the American geranium varieties Irene, Flame Irene, Penny Irene, and Orange Sonne, as pot plants, has been compared in J.I.P.1, and peat/sand composts, on two bench types, as was done with the chrysanthemums. There has been little difference in plant performance between composts, but the greater absorptive capacity of the peat:sand had the advantage that the plants on the wire mesh bench needed 20 per cent fewer waterings than the John Innes mix. Flowering plants marketed in April, June, August and October took ten, seven, six and nine weeks, respectively, at a minimum night temperature of about 10°C (50°F), to reach this stage from being potted as rooted cuttings.

Annuals as Pot Plants

Peat/sand compost was successfully used on a small, non-experimental scale for raising a wide variety of plants for bedding out. The G.C.R.I. formulation is now being used for growing annuals as inexpensive pot plants by giving a night break with low intensity incandescent light to induce flowering during the short days of winter. Plants being grown in this way include *Begonia semperflorens*, *Calceolaria*, *Coleus*, *Petunia*, *Salvia splendens*, and *Tagetes erecta*.

Loamless composts are much less widely used with plants grown in beds and troughs than they are with pot plants. Although problems arise with them in commercial practice—largely because they lack the buffering action of loam, and the tolerance of mistakes which this permits—they are well suited to precise growing techniques. The development of completely standardized mixes, preferably made of manufactured components, in place of naturally-occurring ones, is much to be desired.

It is generally easier and cheaper to amend an existing glasshouse soil to suit the needs of a border-grown crop than it is to replace it with an artificial medium. Nevertheless with the experience gained at Efford as well as other Experimental Horticulture Stations, it should be possible to

provide answers to problems that may arise if and when the use of loamless composts becomes more widespread. So far, our experience has been most encouraging.

TRAINING AND TRIMMING METHODS FOR CUCUMBERS

H. G. Kingham, *N.A.A.S., Cambridge*

The traditional method for training cucumber plants used for many years by commercial growers has been in the form of an arch. This method requires rows of plants spaced at 13–15 ft apart. The plants in each pair of rows are trained over the space between the rows on a wire frame in the shape of an inverted V, to form an arch of foliage. Cultural operations and harvesting are then carried out from the path space beneath the arch.

Traditional arch training can give very satisfactory yields, and allows convenient harvesting of the fruit, which hangs clear of the foliage on the inside of the arch. However, training the plants in this way requires a great deal of skilled labour, and the cordon system which has been generally practised in Holland and Denmark for some years offers a means of reducing labour for plant training by as much as 50 per cent. Since 1961, therefore, experiments have been carried out to determine the most satisfactory means of applying the cordon training method in English conditions.

Comparisons of cordon and arch training
Lee Valley E.H.S. 1962–66

Year	Yield (Arch trained)	Yield (Inclined cordon)
	lb per treatment	lb per treatment
1962 (First crop)	1,408	1,488
1962 (Second crop)	843	911
1963 (First crop)	1,922	1,871
1963 (Second crop)	895	910
	tons per 1/10th acre	tons per 1/10th acre
1966	10·1	9·4
1966 Vertical cordons	—	10·2

The programme was devised firstly to find out whether cordon training could produce yields equal to those obtained by traditional arch training, and the table summarizes comparisions of the two techniques made between 1962 and 1966. It is evident from these comparision that given satisfactory management, yield is not reduced where cordon training is adopted, and this conclusion has been confirmed by the experience of some commercial growers, although there have been cases in commerce where the introduction of cordon training has resulted in depressed yields. Having thus established that cordon training is generally practicable, it is important to compare the different techniques which can be used within this training system, and

assess their yield effects. The major variables which have so far been considered in the programmes at Experimental Stations are planting density and arrangement, height, training method, and inclination of cordon plants.

The cordon plant is supported by twisting the apical shoot round a single string tied to an overhead wire. Experiments at both the Lee Valley E.H.S. and Stockbridge E.H.S. in 1967 showed clearly that lowering the supporting wire so as to reduce the height of the resulting plant to below 6 ft also markedly reduced yield. It is now generally accepted that the height of the supporting wire should be as great as the convenient reach of the operators who train the plants and harvest the fruit. Between the bed and the supporting wire the plant may be taken up vertically, or the string may be inclined at an angle of about 15 deg to the vertical. Alternatively the wires can be offset about 18 in. from the centre of the bed so that the strings incline about 15 deg into the path space. Many practical details of management affect the choice between inclined and vertical cordons, and further variations on both these methods are possible. So far as has been established by experiment, however, none of the possible variants offer any marked advantage in yield. For example, comparisions at the Lee Valley E.H.S. from 1965–67 gave the following total yields per $\frac{1}{10}$ acre for vertical cordons—4·75, 10·95, 12·1, and in the corresponding years for inclined cordons—5·02, 11·0, and 12·75 tons. It is now generally believed that choice between these alternatives should be based upon their adaptability to different types of glasshouse and general convenience in handling, rather than yield factors.

Finally, in considering cordon training, the effects of planting density and trimming method also have to be assessed. It has been shown at both the Lee Valley and Stockbridge House E.H.Ss that increasing the planting density of cordons from 4,000 plants per acre upwards, increases in yield are obtained up to the maximum density tried (6,000 plants per acre). As the density of planting is increased, however, the cost of bed construction, plant propagation, and crop management are also increased, and the optimum density for most practical reasons is thought to be in the region of 5,000 plants per acre. Similarly, various trimming methods have been compared experimentally, with surprisingly little difference between those which involved frequent stopping and 'hard' trimming, and others which allowed growth to develop freely, with very light trimming. These results appear to conflict with commercial experience, where yield variations are often correlated with different levels of skill between operatives, and further experiments are needed on these lines.

PERMANENT UNDERGROUND STEAMING MAINS

F. G. Smith, *Stockbridge House Experimental Horticulture Station*

From the point of view of efficient pest and disease control there can be little doubt that partial sterilization by steam is one of the most satisfactory ways of controlling soil-borne pests and diseases in tomato borders. This is particularly so where potato root eelworm is one of the pests needing to be

controlled. The difficulty with all forms of soil sterilization is that of re-infestation from soil depths greater than those reached by sterilants.

The main objection to soil sterilization by steam is its cost, but this objection was partly met by the advent of sheet steaming which cut out the hard labour involved in the burying of steam injection pipes or even steam ploughs, but the chief disadvantage of sheet steaming is the difficulty in obtaining adequate penetration. Loss of penetration means that the reservoir of sources of reinfection are greater and are brought nearer to the soil surface, thereby reducing the volume of soil in which plant roots can remain healthy. Effective sheet steaming then depends on being able to push the steam from the soil surface downwards to a satisfactory depth. In doing so it gradually replaces the soil air but the steam condenses and some of the soil spaces are replaced by water so that eventually the passage of the steam is choked. It seemed logical, therefore, to ensure a greater depth of penetration and the faster passage of steam through the soil by introducing it below the soil surface. If this was to be done and the low costs of sheet steaming retained, then something in the nature of permanent underground steaming mains was required.

In the early post-war years a method of heating frames by introducing free steam into the soil from tile drains was developed by Lowe of Musselburgh and variations on this method had also been tested at Stockbridge House during the early years of the Station. Experience had shown that it was possible to bring the temperature of the soil up to that of boiling point of water, if the steam injection was continued long enough. Permanent underground steaming mains had also been tried in the past on other commercial holdings. By using permanent underground mains in combination with a steaming sheet the duration of steaming can be prolonged, because steam escaping to the surface is retained below the sheet and re-enters the soil helping to raise its temperature and increase the volume sterilized from a single main. With prolonged steaming the width of the steam front also continues to expand. Previously it had been determined that Hoddesdon pipes should be spaced not more than 20 in. apart if steaming is to be achieved to a uniform depth. Such a frequency of permanent underground mains would be excessively costly but it has now been shown that underground mains spaced 5 ft apart and used with a sheet will give adequate penetration to a reasonably uniform depth. Incidentally, it has further been shown that if the steaming sheet is covered by a net after ballooning has taken place, small increases in pressure inside the sheet can be achieved and this in turn helps to increase the depth of steaming, and tends to cut down the time required to achieve the depth of penetration desired.

In laying permanent underground steaming mains at Stockbridge House trenches have been cut 18 in. deep and 3 in. land tiles have been laid in the bottom of these trenches. The tiles are then just covered with $\frac{3}{4}$ in. granite chippings which hold them in place and ease the free distribution of steam escaping from the joints between the land tiles. The granite chippings themselves are covered with 2 in. of fairly coarse peat which prevents the fine soil falling down between the chippings. The ground at Stockbridge House E.H.S. is level and tiles are laid without any fall on them; the soil is sandy and drains reasonably freely. In heavier soils it may be necessary to arrange for a fall on the underground steaming mains (lines

of land tiles) so as to get rid of condensate water. The steam is fed into these underground mains by opening up the end and introducing a flexible rubber steam hose into the end of the main, and then closing the end again with soil. We are satisfied that mains 35–40 ft in length may be satisfactorily fed with steam to give fairly uniform distribution over the whole length. It is possible that longer mains can be used, depending on the volume and pressure of steam available, but these details have not yet been worked out.

8,820 land tiles are required to provide underground steaming mains at 5 ft intervals over one acre of land. The cost of these tiles is approximately £150, and the cost of laying these may be set against the labour costs of a single steaming by Hoddesdon pipes.

PRODUCTION OF WATERCRESS WITH PROTECTION

R. L. Tite, *Lee Valley Experimental Horticulture Station*

In England the production of watercress in mid-winter is substantially reduced, particularly in frosty weather, when cress is pushed into the spring water for protection. Small quantities are available from beds in favourable frost-free areas or from growers who protect their crops with some form of cover. In order to assist watercress growers in providing an adequate supply of good quality cress in winter with the aid of protection, investigations began at the Lee Valley Experimental Station in 1966.

During the first year a preliminary trial was conducted in a mobile structure to determine whether cress could be grown satisfactorily other than in water beds, with some form of protection, and to test a commercially available seed source. Investigations during the winter of 1967 developed the 1966 work.

In 1967 watercress was grown in water and in the border soil. Alongside the ground beds two polythene isolated beds were made containing 2 inches of sterilized border soil and water at 6·1°C (43°F) flowed over these at 20 gal per hour per yard width of bed from 3 weeks after germination, gradually increasing the flow until harvesting. Cress in the border soil was frequently flooded in the later stages of growth from the sides of the beds. Also a commercially available French round-leaved strain was compared with English seed provided by an outdoor grower interested in the 1966 work. The advantage of seed over vegetative propagation is that watercress viruses are not seedborne.

The first sowings in 1967 were made on 21 September and the second on 6 October at $\frac{1}{6}\frac{1}{6}$ oz per sq. yd. A minimum air temperature of 7·2°C (45°F) was maintained to produce a more robust crop than in the higher temperature regimes of 1966; so heating costs were low and at this temperature aphids were not a problem. The growing environment was similar to that in traditional beds covered with a polythene structure. The first sowing took six weeks to harvesting and the second nine weeks. High quality cress

was cut, the quality and output of both types of bed being similar at 12–18 bunches per sq. yd. The crop was marketed as a loosely packed 3 oz bunch in polythene bags.

The ground beds were destructively harvested and resown: the cropping potential for this method is not as high as for stubble regrowth, as germination and subsequent growth is poor in conditions of low light intensity in December and January. The 'water beds' were cut leaving 2–3 inches of stubble which was pushed down in the water to rejuvenate. The growth from this stubble was excellent and produced a second crop in eight weeks after the first harvesting. Lower seed rates than $\frac{1}{16}$ oz per sq yd may be desirable for stubble regrowth as compared with higher rates for a destructively harvested crop.

The main lines of investigation to be continued will be on the production of watercres in polythene tunnels; examining two seed sources—a commercially available French strain as in 1967 and a Lee Valley selection from a similar strain; all the watercress being grown in 'water beds'.

Results obtained up to the present time are encouraging, but further experiments will be needed before recommendations can be made on the suitability of the above techniques for commercial production.

AUBERGINE AND SWEET PEPPER: PRODUCTION IN A HEATED GLASSHOUSE

F. G. Lloyd, *Lee Valley Experimental Horticulture Station*

The demand for aubergines (egg plant) and sweet peppers (capsicum) has risen considerably in recent years, owing in part to an increase in the number of residents from those countries where fruits of these plants are a common food, and also to the increase in foreign travel by many people, encouraging the consumption of a wider range of fruits and vegetables in Britain.

In view of the increasing interest in these crops it was decided to try them at Lee Valley in 1968 for summer production on straw beds in a heated glasshouse.

The glasshouse accommodating the experiment, had been used in 1967 for tomatoes infected with Tobacco Mosaic Virus (T.M.V.) and as work in 1960 had shown that sweet peppers can be severely affected by T.M.V. from infected root debris remaining in the soil, it was decided to grow both crops on straw beds isolated by polythene from the border soil. Although it was not known whether aubergines would be susceptible to T.M.V. infection, this was considered to be a distinct possibility in view of the close botanical relationship of sweet peppers, aubergines and tomatoes. The plants grew very well on the straw beds and there was no evidence of any T.M.V. infection.

Little information was available on satisfactory densities for these crops under glass, but three rows on each $4\frac{1}{2}$-ft wide bed, giving a density of 13,000 plants per acre, proved to be suitable. Each plant was tied to individual fillis-string supports, and to prevent excessive spreading of the growths several horizontal ties were required around each plant.

All the plants grew extremely well; the aubergines reaching 6 ft in height with the main leader continuing to be dominant throughout the life of the crop, and the peppers attaining a height of 4–5 ft. Watering and feeding was by a drip system.

Planting was carried out on 9 May and picking continued for ten weeks from 26 June to 16 September, when the house was required for another experiment.

Aubergine

Two varieties, Money Maker obtained from Japan and a new hybrid No. 24 from France, produced over four pounds of fruit per plant, equivalent to 24 tons per acre. Fruit size and shape varied considerably; the variety Black Beauty having almost spherical fruits, while the variety Long Violet, had long curved fruits. All the fruits, irrespective of shape and size, were well received on the market and returns reflected the high quality obtained. The plants remained healthy with extremely dense root systems.

Sweet Pepper

In this study the most productive variety, New Ace, which was obtained from Japan, produced 5 pounds of marketable fruit per plant, equivalent to nearly 30 tons per acre; the other variety, California Wonder, grown extensively in the open in U.S.A., produced only 2·7 pounds per plant. The shape and size of the fruits of the two varieties were very similar but those from New Ace were shiny and more attractive than those from California Wonder. Some fruits turned red later in the season but the majority were marketed green.

Conclusions

The results were most encouraging and indicated that these crops have a potential for glasshouse production in Britain, especially if marketing can begin in April or May to give a longer season crop with a higher total yield. In continuation of this work aubergines and sweet peppers will be planted in February to investigate the possibilities for early and long season production using early, high-yielding varieties.

In comparision with tomatoes the labour requirement during the growing season was lower as no sideshooting was required, picking was carried out only once each week and some fruits of aubergines weighed ½–1 lb each. This saving would be attractive in view of increasing labour costs.

Before commencing the commercial production of either of these crops, even on a small scale, it is necessary to ascertain that a satisfactory outlet for the fruits can be obtained.

PROPAGATION OF ROSES FOR NURSERY STOCK AND CUT FLOWER PRODUCTION

R. L. Tite, *Lee Valley Experimental Horticulture Station*

The production period for bush roses for sale has traditionally been over a 1½–2-year cycle, planting stocks in the spring, budding the following July for sale 16–20 months later. Rose bushes for sale in containers are usually lifted from the field, but plants with a field root system are not always successful when restricted in a container. A plant grown throughout its life in a container should be more suitable.

Experiments were begun in 1967 at Lee Valley to investigate the production of suitable material for container growing. As long ago as 1960, several varieties of rose were propagated at Lee Valley from soft-wood cuttings and these are now growing as well on their own roots as plants produced by budding on *Rosa canina* at the same time. The use of cuttings overcomes the need to bud on stocks and this method also has the advantage of reducing the time from propagation to marketing.

Cuttings of 9 varieties selected to give varying habit and vigour were taken during mid-August. The cuttings of 1, 2, 3 or 4-bud length were dipped in a semi-hard wood hormone rooting powder and put, 25 per seed tray, in a 50:50 peat:coarse sand mixture. Rooting on a mist bed at a temperature of 21·1°C (70°F) occurred in 2–3 weeks and after weaning, the cuttings were potted in 3½-in. plastic pots in J.I.P.1.

Although there were some varietal differences, the mean percentage rooting for the 1, 2 and 3 bud cuttings was approximately 90 per cent, whereas for the 4 bud cuttings this was 63 per cent. The failure of many of the 4 bud cuttings was due to their greater surface area for transpiration resulting in shrivelling with saprophytic infections starting on dying material. Internodal cuttings produced the more vigorous rooting system.

After potting, the roses were placed in frames 'kept just frost-free' during the winter. In the following spring half the plants were put in the open ground and the others in 7 in. black polythene containers in J.I.P.1 on a capillary bed. Bushes in containers were ready for 'garden-centre' sale from mid-June onwards, ten months from propagation, the majority of plants being ideal for 'instant garden' at this time. In the autumn the container-grown plants were graded against a standard of bought-in bushes budded on *R. canina* the year previously. The percentage of first-grade bushes from cuttings with one one-bud was, generally, lower than from the other cutting lengths where the range was 50–90 per cent.

A number of plants from each treatment have been retained and planted in permanent positions alongside budded bushes bought-in from the same source of the soft-wood cutting material. These will be tested for their suitability for garden use, comparing longevity, habit of growth, flower number and colour, vigour, and resistance or susceptibility to pests and diseases.

Propagation for Glasshouse Flower Production

The total acreage of glasshouse roses for bloom production in January 1968 was 103 acres, 24 per cent less than the 140 acres in July 1966. The majority

of this acreage is in the Lee Valley although this is where the acreage is being lost due to pressure for building land. The trend at the moment is for new growers to take up bloom production under glass on smaller acreages than in the past, and this emphasizes the need to intensify production and increase output during the most profitable periods.

With this in mind an investigation was begun in the spring of 1968 to examine the effect on short to moderate term crops of three propagation methods:

Spring 1968 bench grafted plants on *R. canina*

One-year-old budded bushes on *R. chinensis* 'Major' syn. *R. indica major* (Baccara and Lovita only)

Soft-wood cuttings propagated as for the outdoor experiment in early–late spring 1968

Four varieties were used Baccara (red), Lovita (red), Pink Sensation and Dr. Verhage (golden yellow), and three spacings 10 × 12 in., 10 × 9 in. and 10 × 6 in.

At 36,000 plants per acre, the cost of bench grafted plants is £2,000–£2,600 and budded bushes on *R. chinensis* 'Major' £7,000–£9,000 per acre depending on the number ordered and variety. Soft-wood cuttings are likely to cost less than bench grafted plants. At the moment scion varieties budded on *R. chinensis* 'Major' are imported from the Mediterranean region because this stock is only half-hardy and would not survive a normal British winter outside. It has been used for some years as an understock in the south of France, and gives greater vigour to the scion than clones of *R. canina.*

The experiment is accommodated in a north–south 70 ft × 50 ft heated Dutch light glasshouse. The first plantings took place on 1 April with budded bushes on *R. chinensis* 'Major' of the varieties Lovita and Baccara, ending on 14 May with soft-wood cuttings of the variety Pink Sensation. This was a much later planting than is usual commercially, which is normally completed by mid-February. Flower recording began on 13 June and the total number of blooms produced after 20 weeks is given in the table.

There was a considerable number of losses with the Baccara bushes budded on *R. chinensis* 'Major'. The establishment of bushes on this understock is more difficult than those bench grafted on *R. canina.* They are also more awkward to plant because of the longer rooting system than the other two propagation methods, especially the 2 bud soft-wood cuttings which were planted 3–4 weeks from propagation. Figures show that the bushes on *R. chinensis* 'Major' are ahead in flower number (and probably also quality). Bushes on their own roots are comparing satisfactorily with bench grafted plants, especially if the difference in propagation date is taken into account. The varieties Baccara and Lovita which were propagated earlier, are particularly promising on their own roots, but Dr. Verhage has not responded so well, and this variety has proved to be more difficult to root and establish. Production from the varieties on their own roots has generally been encouraging in the first season from planting, but the testing time will come in the second season when a good framework will be essential for this method of propagation to equal the known bloom potential of bushes on *R. canina* and *R. chinensis* 'Major' in the years after planting.

Table of bloom production

Number of blooms per plot of 45 sq. ft calculated on 100 per cent plant populations

Variety	Propagation method and planting distance	Propagation date	Planting date	Total bloom production 20 weeks
Baccara	Budded on *R. chinensis* 'Major' 10 × 12 in.	Summer 1967	1 April	432
	Grafted on *R. canina* 10 × 12 in.	25 Feb 1968	2 April	294
	Soft-wood cuttings 10 × 12 in.	4 April 1968	25 April	280
	Soft-wood cuttings 10 × 9 in.	4 April 1968	25 April	343
	Soft-wood cuttings 10 × 6 in.	4 April 1968	25 April	357
Lovita	Budded on *R. chinensis* 'Major' 10 × 12 in.	Spring/Summer 1967	1 April	629
	Grafted on *R. canina* 10 × 12 in.	25 Feb 1968	2 April	358
	Soft-wood cuttings 10 × 12 in.	22 March 1968	17 April	341
	Soft-wood cuttings 10 × 9 in.	22 March 1968	17 April	349
	Soft-wood cuttings 10 × 6 in.	22 March 1968	17 April	421
Pink Sensation	Grafted on *R. canina* 10 × 12 in.	15 Feb. 1968	8 April	494
	Soft-wood cuttings 10 × 12 in.	18 April 1968	14 May	359
	Soft-wood cuttings 10 × 9 in.	18 April 1968	14 May	430
	Soft-wood cuttings 10 × 6 in.	18 April 1968	14 May	447
Dr. Verhage	Grafted on *R. canina* 10 × 12 in.	27 Feb. 1968	8 April	406
	Soft-wood cuttings 10 × 12 in.	21 March and 17 April 1968	22 April and 14 May	260
	Soft-wood cuttings 10 × 9 in.	21 March and 17 April 1968	22 April and 14 May	269
	Soft-wood cuttings 10 × 6 in.	21 March and 17 April 1968	22 April and 14 May	326

Plants per plot: 10 × 12 in. = 50
10 × 9 in. = 65
10 × 6 in. = 100

THE POT CARNATION

R. F. Harnett, *Efford Experimental Horticulture Station*

As flowering pot plants become increasingly popular, growers of them take a continuing interest in new types to expand their range. New techniques, such as the use of growth regulators to control plant height and methods of timing the production of blooms by increasing or reducing day-length have meant that plants hitherto unsuitable for pot growing can now be a useful addition to the pot plant list.

The perpetual flowering carnation can be likened to the chrysanthemum and poinsettia as a programmed year round pot plant. As a cut flower the carnation is well established and this should make the sales promotion of a growing plant comparatively easy. With good variation in flower colour and the special attraction of perfumed varieties with good keeping qualities, it is possible that the carnation may compete with the pot chrysanthemum.

Varieties suggested as being suitable by Steven Bailey, the carnation specialist, were sent to the Glasshouse Crops Research Institute for virus testing before experiments began at Efford. In the autumn of 1967, Bailey's Splendour, a pink variety, was the first to be grown to find if there was any response in reduced height, following the application of the growth regulators, Phosphon, B-Nine and Cycocel at the rates recommended for pot chrysanthemums. No effect was noted at these levels, so the rates were increased in the next experiment in May, 1968. Rooted cuttings of Bailey's Apricot as well as Splendour were potted into 3-in. clay pots and grown on an irrigated sand bench with the pots set 9 in. square. Day and night temperature was 12·8°C (55°F) and ventilation commenced at 15·6°C (60°F). Plants were stopped at four-leaf pairs and all breaks were allowed to mature. The terminal buds were removed as soon as they were large enough to handle to allow axillary buds to form a spray. Cycocel, at 0·6 per cent a.i., was the only chemical to have any effect in reducing height; application on four occasions as a soil drench at 2 fl. oz of the diluted material per pot gave a flowering plant 12 in. tall, 8 in. shorter than untreated plants. Cycocel also hastened flowering compared with untreated plants.

In the next experiment it was decided to concentrate on Cycocel, and try to determine when and how many soil drenches should be applied. This time, instead of allowing all the breaks to mature after stopping, only the two most vigorous shoots were retained in an effort to bring both into flower at about the same time. Two dilution rates, 0·6 per cent and 0·9 per cent a.i. were applied at monthly intervals from potting the rooted cuttings to flowering. In addition, half the plants were given dusk to dawn lighting with incandescent tungsten filament bulbs commencing when the axillary shoots were showing four leaf pairs and continuing for eight weeks. This was compared with plants growing through the winter in natural short days. It has been established with the cut flower crop that 24-hour lighting will hasten flowering and initiate flowers on the same plant in a shorter period, and these two factors are desirable for pot plant work. Plate V shows the effect of Cycocel at 0·9 per cent a.i. applied on four occasions compared with an untreated plant, both with and without

lighting. The lit plants are about to flower but the unlit plants have yet to have their terminal buds removed.

There is, of course, still much experimental work to be done before commercial production for market can commence. Indications point to the use of higher rates of Cycocel applied at the most critical period in the growth of the plants. At present there appears to be a lack of uniformity between two plants similarly treated. This may be due to the age or type of cutting taken, and will be more closely investigated later. A wider selection of varieties will also be looked at, including natural spray types such as Elegance and Royalette. Cuttings will probably be struck into small containers and potted up after stopping to allow for a greater throughput. It is envisaged that the first marketable pot plant will consist of three plants in a $5\frac{1}{2}$-in. half pot giving 36 flowers. Plate V shows a plant of this kind. What will this pot cost to produce? It is too early to give a precise programme of throughput, but it seems likely to be only three fifths that of the pot chrysanthemum. However, growing temperatures are lower and less sophisticated equipment is required, therefore the final cost per pot may not be very much more than for the pot chrysanthemum.

ALL-YEAR-ROUND POINSETTIAS

R. L. Tite, *Lee Valley Experimental Horticulture Station*

The poinsettia has for long been the symbol for Christmas in the U.S.A. and over the last five years has become increasingly popular in this country. The variety Paul Mikkelsen and its types with their ability to survive (sometimes for long periods) varying domestic conditions has superseded the older Ecke strains that were likely to defoliate as soon as environmental conditions changed. However, in 1968 improved Ecke and Mikkelsen strains were becoming available with varying habit and bract colour.

Formal experiments began in August 1967 at Lee Valley and have continued since that time to investigate all-year-round production. The variety Paul Mikkelsen was chosen to mature for the Christmas market. Potting was in mid-August, earlier than usual, so that the effect of a range of growth depressants on plant height could be examined. Four composts were used, J.I.P.1 (with half the calcium carbonate omitted); soil, peat, perlite (1:1:1); G.C.R.I. peat sand mix and a proprietary peat, sand, grit mix. Three growth depressant treatments were applied, Cycocel 0·25 per cent a.i. as one soil drench, two overhead sprays of Cycocel 0·25 per cent a.i., and one overhead spray of Cycocel 0·25 per cent a.i. plus B-Nine 1 per cent a.i., with an untreated control for comparision. Two pot sizes were used, a $4\frac{1}{4}$-in. plastic pot with one plant or a $5\frac{1}{2}$-in. plastic half-pot containing three plants.

It was found that the J.I.P.1 and G.C.R.I. compost with either two overhead Cycocel sprays or one overhead Cycocel plus B-Nine produced the most satisfactory plants. A considerable amount of leaf chlorosis was seen especially in the peat-based composts, this being attributed to root disturbance and damage largely caused by sciarid fly larvae grazing on the roots.

The next series began in early March 1968 with three successive plantings at three-week intervals to mature from mid-May to early July. Again Paul Mikkelsen was the variety chosen, the treatments being two pot types, $4\frac{1}{4}$-in. plastic or clay pots, four composts, J.I.P.1 (with half the calcium carbonate omitted), a proprietary all peat compost, G.C.R.I. peat sand compost and G.C.R.I. peat, sand, grit compost. Three levels of nitrogen were applied in liquid feeds, 100 p.p.m. N, 200 p.p.m. N and 400 p.p.m. N. An application of the growth depressant Cycocel 0·25 per cent a.i. was given to all treatments two weeks after potting and periodic soil drenches of parathion to control root fly larvae. From each potting date plants received two weeks of long days to encourage even vegetative growth before short days (14-hour night) commenced to initiate the flower buds and subsequent bract formation.

In this series, the proprietary all peat and G.C.R.I. peat sand composts gave the best results. It is more difficult to 'flower' the poinsettia on schedule with increasing temperatures (especially under the black cloth or polythene used to regulate day-length) which also inhibit bract coloration. It was found however that the higher the nitrogen level (high cF in the soil) the better the plant and its ability to bract up and colour on time (Paul Mikkelsen 10 week response group). For early July marketing, the high rate of nitrogen (400 p.p.m.) was the only successful treatment, which seems to confirm the reputed characteristic of this plant as a gross feeder.

The fifth run of experiments began with planting in mid-September in three composts, J.I.P.1 (with half the calcium carbonate omitted), a proprietary all peat compost and G.C.R.I. peat sand compost. The same three levels of nitrogen were applied in feeds as in the previous year, with 100 p.p.m. K_2O included with each. Three growth depressant treatments were applied, Cycocel 0·25 per cent a.i. as one soil drench, Cycocel 0·25 per cent a.i. as two overhead sprays, and one overhead spray of Cycocel 0·25 per cent plus B-Nine at 1 per cent a.i. An assessment of these plants before they reached maturity showed that the combined Cycocel and B-Nine was giving the best height control and the higher nitrogen levels the better quality plants.

GERANIUMS—PRODUCTION FROM SEED

Enid A. Turner, *Luddington Experimental Horticulture Station*

The most widely adopted method of propagating geraniums has been and still is by the use of cuttings taken in the autumn or early spring. In recent years more interest has been taken in the production of plants from seed. Early attempts to produce good plants were not always successful as the quality of the blooms was poor and flowering was delayed. In America work has been done on the production of F_1 hybrids that can be grown from seed to produce very good quality plants in the minimum of time. This seed is now available in Great Britain and growers have been using it to try and shorten the propagating time needed for these plants and still get marketable plants for May and June, the peak demand periods.

At Luddington trial batches of the F_1 hybrids were grown in 1967 and 1968 and a summary of the results obtained is given below.

In 1967 the seed was obtained direct from America and five colours were grown. These were scarlet, white, rose pink, light pink and salmon, all came true to colour and produced very large, well shaped blooms.

The seed was sown on 23 January in a loamless compost and germinated in a propagating case. The temperature in the glasshouse was a minimum of 18·3°C (65°F) but the temperature in the case was a few degrees higher. Germination was very good and as soon as the seedlings could be handled they were potted up in $2\frac{1}{4}$-in. pots again using a loamless compost. At all times the aim was to keep the plants growing quickly and when ready, they were moved into $3\frac{1}{2}$-in. and then $4\frac{1}{4}$-in. pots, using a J.I.P.2 compost. No 'stopping' or pinching of the plants was done and although the plants were rather tall when marketed the side shoots were growing well and the appearance of the plant was balanced and good.

The plants were marketed in the $4\frac{1}{4}$-in. pots. The first flowers were opening on 27 May and marketing started during the first week of June, when plants had one flower head open and showing the true colour. This meant that under Luddington conditions it took 124 days from sowing to flowering, a slightly longer time than in America where plants had the advantage of better winter light conditions, and a time of 100–110 days is more usual. In America where additional lighting was given during the growing period this time was reduced to 60–70 days.

At Luddington in 1968 an attempt was made to bring the plants into flower earlier by altering the sowing date. Sowing took place on 23 December 1967, and the plants were grown under similar conditions to those of the previous year. A larger plant resulted earlier but no flower heads were produced until May 1968.

The time from sowing to flowering was increased with a resulting increase in production costs and the January sowing date would appear more suitable. Where an earlier bloom is required the use of lighting could be tried but this has not yet been possible on the Station.

Each year a number of plants were planted out in a border and subjected to the vagaries of an English summer, and even in 1968 when climatic conditions at Luddington were poor, the plants made good growth and produced a succession of blooms which kept their colour until the plants were cut down by frost in late October.

A number of plants were marketed through the wholesale market and the quality and size of plant compared favourably with those produced from cuttings.

At the moment little information is available on the production of geraniums from seed and more work needs to be done to shorten the period from sowing to flowering and to ascertain the economics of this method of growing. There are real advantages due to the absence of disease and virus in the plants and as breeding work continues the range of colours and types may be increased.

PRODUCTION OF CHRYSANTHEMUM STOCK FREE FROM ASPERMY VIRUS

T. Fenton, *Fairfield Experimental Horticulture Station*

In order to make valid comparisons such as are required in experimental work, it is important to ensure that stocks used for this purpose are as disease-free as possible. Early investigations at Fairfield showed striking differences both in occurrence of flower distortion and in plant vigour between heat-treated and untreated chrysanthemums, due to the control of virus infection afforded by the heat treatment. Because of this it was decided that all existing stock on the station together with any new stock obtained should receive heat treatment. A small nucleus of clean stock held under special hygienic conditions would be maintained to replace any variety in the general commercial collection which became re-infected.

Treatment and Effect

Young growing plants are subjected to a temperature of 37·2°C (99°F) for a period of 4 weeks. The effect of this high temperature is to reduce the multiplication rate of the virus, yet the ability of the plant to inactivate the virus is not greatly impaired. As the greatest reduction or elimination of the virus occurs in the extreme tips of the shoots, only very small cuttings are subsequently used for propagation.

Construction of Heat Therapy Unit

Two hot boxes are in use at Fairfield for treatment of chrysanthemum plants, each being 11 ft 3 in. × 3 ft 9 in. × 3 ft 9 in. high (see Plate VI). The construction allows easy access to all parts. The boxes are heated by 'Pyrotenax' cables which have a high heat output with quick response and which are controlled by shielded rod thermostats to maintain the required temperature without wide fluctuations.

The plants in $4\frac{1}{4}$-in. plastic pots are stood on slatted benching which is raised about 9 in. above the floor of the boxes. Immediately below the benches are plastic troughs which are kept at a constant water level from a tank outside the box. Water is supplied to the plants by means of nylon-felt wicks inserted into the pots. This method has given a marked improvement in the number of plants surviving treatment as compared with hand watering on a solid bench. Very little opening of the box during treatment is necessary, and changes in temperature are thus avoided. Checks using thermocouples have indicated only small variations (± 1·1°C) in temperature in the area occupied by plants. The glasshouse accommodating the hot boxes is given a light application of shading to avoid excessive build-up of temperature due to direct sunlight.

Method of Treatment

The most suitable plants for heat treatment are those raised in a temperature of 12·8°–15·6°C (55°–60°F), which have normal healthy foliage and are

growing in a J.I.P.2 or equivalent compost. Plants which have soft growth or those grown hard are both unsuitable, as the foliage will suffer unduly.

Prior to treatment, the plants are stopped when 4–5 in. in height to produce three laterals which are again stopped when about 4 in. long, immediately before the plants are placed in the box. At the same time all mature leaves on the main stem are removed as it has been found that these are liable to collapse during the period of treatment. In order to avoid severe damage to the plants, the temperature of the hot box should be raised gradually after the plants are introduced. It has been found in practice that damage is avoided as far as possible if the temperature is raised gradually to 37·2°C (99°F) over a period of about 7 days. The plant tissue deteriorates during the period of treatment, but cuttings $\frac{1}{4}$–$\frac{1}{2}$ in. long taken from the tips of the shoots soon recover as rooting takes place. This is encouraged by the use of rooting hormones, bench warming and mist irrigation.

Testing of Treated Stock

Each clone is indexed individually so that should one be found to contain a reactor then all material from that clone is destroyed. Out of some 3,000–3,500 tests made on stock treated at Fairfield over the past 5 years only one reactor has shown up. The tests have been carried out by the N.A.A.S. Plant Pathology Department at Leeds.

Maintaining Clean Stock

Tested stock is accommodated in an insect-proof house and weekly applications of insecticides and fungicides are given to maintain a high standard of hygiene. Plants are subjected to low temperatures during the winter as the behaviour of certain varieites, e.g., Balcombe Perfection, Festival, Fred Shoesmith has suggested that de-vernalisation may result from heat treatment.

CONTROL OF PERENNIAL WEEDS IN TOP FRUIT

R.E. Tremeer, *Efford Experimental Horticulture Station*

Orchards provide ideal conditions for the development of perennial weeds, and with the present trend being more and more towards intensively planted systems of top fruit growing, the problem of controlling such weeds is becoming more acute. Indeed the success of closely planted apples on the spindlebush system, for example, with densities of up to 1,000 trees per acre, may well depend on the ability to control weeds efficiently. At such close planting, it is obviously essential for the roots to be able to exploit fully the soil profile, particularly the fertile top few inches. This means no root disturbance and no competition from weeds. In other words, the aim is complete weed control by the use of herbicides.

Perennial weeds, by their very nature, are more difficult to control than annuals. Many of them have deep roots capable of vegetative reproduction, and even if the aerial parts are killed, the root system with an adequate reserve of food is capable of re-growth. However, repeated killing of the aerial parts will eventually weaken and kill the root system, and this principle can be used for the control of some perennial weeds, e.g., couch. This method is time consuming and expensive, and a once-and-for-all kill is obviously preferable. In addition to the facility of vegetative reproduction, some perennial weeds, e.g., docks, also reproduce readily by seed. Whatever the weed, an appreciation of its biological characteristics is required before intelligent control measures can be applied.

The perennial weeds that are of concern to top fruit growers vary from one orchard to another, but the most common are the rhizomatous grasses, such as *Agropyron repens* (couch), thistles, bindweed, docks and sorrels, knotgrass, creeping buttercup, perennial nettles, coltsfoot, horsetails, ground elder, dandelion, and occasionally bracken and brambles. In orchards where annual weeds are controlled by herbicides (frequently a mixture of paraquat and simazine is used), the resistant perennial weeds grow away vigorously, lacking competition from the annuals.

Although there are a number of herbicides capable of controlling most weeds, none of them is completely safe for use under top fruit. Thus many perennial weeds can be killed by the growth-regulator type of herbicide such as MCPA, 2,4-D, mecoprop and 2,4,5-T. Unfortunately all top fruit crops are very sensitive to these materials, although the degree of sensitivity varies widely. Cox's Orange Pippin is more resistant to 2,4-D than it is to MCPA, while Bramley's Seedling is equally susceptible to both materials. Pears generally are more susceptible to 2,4-D and MCPA damage than apples. The difficulties with the use of growth regulator type of herbicides are (1) the possibility of drift on to the crop trees, and (2) the vapour risk from these volatile compounds if used during hot weather, but provided they can be applied under cool, wind-free conditions, using a coarse spray and a high gallonage (e.g., $2\frac{1}{2}$ pints in 100 gallons per sprayed acre), the dangers are lessened and a good control of bindweed and most broad-leaved perennial weeds can be achieved. At Efford, MCPA applied in June when the weeds are growing vigorously has given a good control of thistles and docks. The spectrum can be broadened by using mixtures, such as CMPP + 2,4-D. 2,4, 5-T will give a good control of perennial nettles and brambles, but particular care is needed when using this material, which is a tree killer in its own right, and as with all the hormone type herbicides it should not be used during the blossom period. However, used intelligently, these herbicides can play an important role in the control of perennial weeds in orchards. They also have the advantage of being relatively cheap. Moreover, the sodium, potassium or the amine forms of these materials, e.g., the amine formulation of 2,4,5-T, are much less volatile and are, therefore, safer to use than the original ester formulations.

Apart from the growth regulator type herbicides, a number of the newer materials have been under test at Experimental Stations for several years. At Efford E.H.S. these herbicide trials started in 1961, with the aim of assessing their efficiency in controlling weeds and to look for possible harmful effects on apple and pear trees. This work has been of an observational nature only, as fundamental work on the resistance of fruit trees

to herbicides, and the possible long-term effects of the repeated use of herbicides, is being done at the research stations, notably at East Malling. In 1967 a uracil herbicide gave good control of annual and some perennial weeds, but at both 2 lb and 4 lb a.i. per acre this material produced leaf damage on Conference pears, leading to some defoliation late in the season. The related material bromacil was under trial in 1968; this gave a good control of most weeds at 2 lb a.i. per acre, but creeping buttercup and thistles appeared partially resistant. There was also an indication of damage to the leaves of William, Bon Chretien and Conference pears so that further trials with bromacil will be necessary.

In 1968 a mixture of aminotriazole and diuron, was used at Efford for the first time under apple and pear trees. Aminotriazole has been used for several years, primarily as a grass killer, but with good activity against some broad-leaved weeds, such as docks and thistles. It will also check coltsfoot, creeping buttercup, perennial nettle and sorrel. Although diruon was formerly recommended as safe for use under apples and pears, it was largely superseded by simazine which was cheaper. However, diuron has the advantage of being effective against knotgrass, orache, and creeping buttercup, all of which are resistant to simazine. When diuron and aminotriazole are used together there is thought to be a synergistic effect, i.e., a wider range of weeds is controlled and more quickly, than when both materials are used separately. At Efford the mixture gave an excellent control of weeds at both 9 lb a.i. per acre and at half this rate and warrants further testing particularly to assess its value in controlling perennial weeds. It is likely to be of particular value where a wide range of perennial weeds occur or where simazine resistant weeds have built up. Disadvantages of this material are (1) its time of application is governed by the clearance given for aminotriazole, ie., before petal fall or after harvest, and (2) aminotriazole is not recommended for use under trees planted for less than four years.

The two related materials dichlobenil and chlorthiamid are both highly toxic to germinating weeds and to the buds and shoots arising from below ground portions of perennial plants. Dichlobenil, when used as a wettable powder, is rather volatile and quickly disappears from the soil. Chlorthiamid, which is less volatile, is thought to be converted to dichlobenil in the soil, and in practice, when applied in granular form there is very little difference between the two. Although these materials give a good control of annual and perennial weeds, marginal chlorosis of the leaves of both apples and pears has been observed at Efford (even when used at the low rate of 2 lb a.i. per acre in the case of Conference pears). Stone fruits are said to be even more susceptible to marginal chlorosis than apples and pears. There is no indication at Efford of any retardation of growth or loss of crop associated with this marginal chlorosis, but the possibility of long-term deleterious effects from the use of chlorthiamid and dichlobenil in top fruit cannot be ruled out. Nevertheless they can give an excellent, though rather expensive control of many perennial weeds, and being in a granular form are particularly suitable for spot treatment of perennial weeds which cannot be controlled by routine spraying with the safer materials simazine and paraquat.

The herbicide work at Efford is part of a continuing programme, and as new promising materials become available they will be included.

The importance of planting up an orchard into clean land cannot be too strongly emphasized, and with the herbicides available today this can now be more easily achieved. If the previous crop was corn or a grass ley, then broad-leaved perennial weeds could have been eradicated with hormone type herbicides without damaging the crop. However, where the grower is faced with the problem of planting a piece of land in which perennial weeds have not been controlled in the previous crop, a herbicide programme can still be used to clear up the land. In such a situation a suggested programme is aminotriazole, plus a broad spectrum hormone weed killer, applied as soon as active weed growth starts, followed one week later by a contact herbicide such as paraquat. After an interval of two weeks the ground should be rotovated, leading to the germination of further weeds which could be eradicated with paraquat. A further aminotriazole plus hormone spray might be necessary. The particular herbicide programme can be varied but provided the grower makes a concerted effort and is prepared to 'lose' a year, then perennial weeds need not be a problem in newly planted orchards.

Although the emphasis in this article is on the control of perennial weeds by herbicides, this does not mean that mechanical methods of control have no place in top fruit growing today. Before planting up new orchards certain perennial weeds, e.g., couch, might be most efficiently eradicated by cultivations or a combination of chemical and mechanical measures. In some traditional orchards where weeds are controlled by shallow summer cultivations, weeds growing immediately beneath the trees can become a problem. Here again a combination of mechanical and chemical methods can be used to advantage. The timely physical removal of young brambles and other woody perennial weeds, best done at the same time as the winter pruning, is still very much worth while. Herbicides are a valuable tool, but are not yet the complete answer to the problem of controlling perennial weeds in top fruit growing.

AMERICAN GOOSEBERRY MILDEW INFECTION ON BLACK CURRANTS

J. Ingram, *Luddington Experimental Horticulture Station*

American gooseberry mildew infection casued by the fungus *Sphaerotheca mors-uvae* (Schw. Berk) has been an increasing problem to the black currant grower and effective control of the disease is necessary in order to maintain a satisfactory cropping performance. Severe infection leads to leaf distortion, premature defoliation and death of terminal buds with a consequent reduction in extension growth. In addition, work at Long Ashton Research Station has shown that buds on severely infected shoots contain fewer flower initials than buds on healthy shoots. Severe infection leads to a reduction of crop in the current year and the loss of extension growth and reduction in the number of flower initials causes an even more pronounced loss of crop in the following year.

Varietal susceptibility

The main varieties grown commercially in this country are all susceptible to the disease. Some varieties of more recent introduction such as Brodtorp, Gerby, Ojebyn and Risager show apparent resistance to mildew infection and some of these also appear to be resistant to leaf spot (*Pseudopeziza ribis* Kleb).

The disease resistance in these varieties appears to be closely linked genetically to the less desirable character of a rather spreading bush habit. Some of these varieties are being used in breeding programmes at the Scottish Horticultural Research Institute and at Long Ashton Research Station.

Spraying Trials at Luddington

Materials

With the increasing incidence of mildew infection on black currants, trials to compare fungicidal materials and programmes began at Luddington in 1964.

The early trials showed the material quinomethionate (Morestan) to be the most effective fungicide, followed by lime sulphur, dinocap (Karathane or Crotothane) and colloidal sulphur in decreasing order of effectiveness. In addition to controlling mildew, quinomethionate and to a less extent lime sulphur, were shown to be effective against leaf spot.

In 1966 the new material PP. 781 now identified as drazoxolon (Mil-Col) was introduced into the trials and proved to be as effective as quinomethionate against both mildew and leaf spot. In 1967 and 1968 drazoxolon continued to provide a good control of both diseases but quino methionate failed to maintain a satisfactory performance against mildew while remaining fully effective against leaf spot. Over the period of trial drazoxolon has thus proved to be the most effective fungicide for both mildew and leaf spot control, whereas dinocap, although moderately effective against mildew has provided no control of leaf spot. The cheapest programme, 1 per cent lime sulphur + wetter has given a moderate control of leaf spot but has caused some loss of crop.

Application of a single high volume spray of quinomethionate at 1 lb 25 per cent material per 100 gal to a range of 22 black currant varieties showed that while the material could be safely applied to the main varieties including Baldwin and Wellington XXX it proved to be too phytotoxic on five of the varieties. These were Brodtorp, Laxton's Giant, Risager, Roodknop and Seabrook's Black. No obvious phytotoxic effect has been observed on the varieties Baldwin and Wellington XXX following applications of drazoxolon and the performance of this fungicide on the 22 varieties is to be observed in 1969.

The table on p. 104 gives details of some of the fungicides compared with rates of application and disease assessments.

In a preliminary screening of new fungicides carried out on black currants in 1968 the material benomyl (Benlate) gave a satisfactory control of both mildew and leaf spot and will be compared with drazoxolon in 1969.

The regrowth made by bushes cut down completely for mechanical harvesting is particularly susceptible to mildew infection which if allowed to develop can lead to death of the plant. Trials have shown that an application of 10 per cent lime sulphur or 6 per cent tar oil should be made

as soon after harvesting as possible followed by a protective fungicide application to the regrowth 14 days later, repeating if necessary.

Black currant American gooseberry mildew (Materials) trials

Fungicide material and rate per 100 gal	Approximate cost of material per acre for 4 applications at 250 gal/acre 1968	Mildew assessments			% Leaf spot infection*		
		% mildew infection	% healthy leaves				
		Oct 1966	Aug 1967	July 1968	Oct 1966	Sept 1967	Aug 1968
dinocap as 1 lb 25% Karathane	£7	54	10	71	32	8	41
quinomethionate as 1 lb 25% Morestan	£15	21	11	47	<5	<5	<5
1 gal lime sulphur + 4 fl. oz succinate wetter as 60% Manoxol	£5	36	15	79	26	7	35
drazoxolon as 2 pints 40% Mil-Col	£12	17	23	87	<5	<5	<5
Control unsprayed for mildew	—	100	1	43	94	16	73

*Based on key by Clarke, G. M. and Corke, A. T. K. in Long Ashton Research Station report for 1955.

Timing of sprays

The first mildew infections were observed at Luddington on 21 May 1965, 11 May 1966, 9 May 1967 and on 23 May 1968. They have usually followed a period of hot dry weather.

Spray timing trials have shown the need for a protective fungicide programme to commence as soon as infection is seen and to continue at 14 day intervals, ensuring that the stipulated interval between the last application and harvest is observed. With drazoxolon the last spray must be applied not later than 4 weeks before harvest, with quinomethionate 2 weeks and with dinocap a 1 week interval should be observed. Where the fruit is destined for processing the processor should always be consulted about the application of spray materials; in the case of lime sulphur no more than three applications after flowering are permitted and the last must not be applied later than 4 weeks before harvest.

An outline programme for the control of American gooseberry mildew on black currants based on the trial results can be summarised as follows:

(a) *On conventional fruiting bushes*

1. Commence protective foliage sprays during early May. Repeat sprays during May and June at intervals of 14 days ensuring that the stipulated time interval between the last application and harvest is observed.
2. Post-picking sprays may be required depending on the incidence of mildew and weather conditions.

(b) *On bushes cut down completely for mechanical harvesting*

1. Apply 10 per cent lime sulphur *or* 6 per cent tar oil as a stool treatment within one week of cutting the bushes down for harvest. This should be followed by a protective fungicide spray applied during the second week of August, repeating on one further occasion if necessary 14 days later.
2. In the following growing year the protective fungicide programme should commence during the second week in May and continue at 14–21-day intervals until the end of August.

All the trials have been carried out in collaboration with P. Wiggell of the N.A.A.S. Area Laboratory, Evesham.

VEGETABLE EXPERIMENTS ON PEAT SOILS

Audrey M. Williams, *Arthur Rickwood Experimental Husbandry Farm*

Work on vegetable crops of special importance to the fenland grower began in a modest way in 1965 at Arthur Rickwood with variety testing of maincrop carrots.

Since those early days there has been a gradual increase in the area assigned to vegetable experiments, which now form part of a six-course rotation to include winter and spring cereals, sugar beet and potatoes. The main vegetable crops now being studied are onions, carrots and celery. These form the major proportion of farm scale vegetables contributing to the pattern of fenland farming.

Onions

The importance of being able to fully mechanize production has led to a study of variable plant populations in 10, 15 and 20-in. single rows, twin rows at 20 in. centres and 4-row beds at 30-in. centres. The effect of these spacings on the yield of ware sized onions and their relative maturity is being studied.

Work on herbicides in 1967 with confirmatory results in 1968, has shown that pre-emergence propachlor at 4 lb a.i. per acre plus chlorpropham at 2 lb a.i. per acre, followed by post-emergence application of pyrazon and chlorbufam at 1·8 lb a.i. per acre gives a good degree of weed control. Of the weed species present in the 1968 trial, only *Chenopodium album* (fat hen) survived in any quantity, and these in fact did become an embarrassment later on in the life of the crop. Further work, particularly with post-emergence herbicides is planned.

In a well grown crop of spring sown onions, drilled early enough to ensure 'bulbing' during the long days, the green tops should die down naturally towards the end of August, at which time they are considered to be ready for harvest, but on peaty soils natural die back is often delayed. A study was made of different methods of treating the foliage in order to procure a crop ready for harvest by early September. Comparisons were made on a small plot scale between low topping (through the sheath), high topping (above the sheath), bending over the foliage at the neck and chemical desiccation of the foliage, all at two weeks prior to harvest.

Low and high topping were also carried out one day before harvest. All these practices were applied to rooted and undercut bulbs. Samples from all treatments are being examined in store periodically to determine the percentage of marketable bulbs remaining.

The ability to produce and retain two to three good skins on an onion is a desirable feature of a successful crop for market. In a comparison of weekly lifting dates from 8 August to 3 October, there were much improved skins from the early harvests, even when only 10–20 per cent of the tops had died down naturally. Excessively wet weather conditions for the onion harvest in the autumn of 1968, will undoubtedly have contributed to the higher incidence of skin splitting and peeling found in the later harvested plots in that year.

Variety testing has shown differences in skin quality and colour, in addition to variations in yield. Stocks which appeared to combine good skins and yield under the black fen conditions at Arthur Rickwood in 1968, include Hebride 'C', Wijbo, Fenman, Wolska, Dura, Constanta, Robusta and one of the Rijnsburgers.

Carrots

Fifty stocks were included in the 1968 N.I.A.B. variety trial, grouped for type and maturity as Amsterdam, Nantes, Chantenay/Danvers, Berlikum/Feonia/Imperator group and Autumn King.

The production of a specified size and shape of root for a particular outlet namely pre-pack, canning, processing or the fresh trade, requires optimum plant populations and density arrangements coupled with a sensible choice of varieties. These requirements form the basis of future experimental work on this crop. There is also considerable interest in successful field storage, to enable a marketable crop of good quality carrots to be harvested through into the spring.

On twin row carrots at 30-in. centres, various methods of earthing-up the crop using potato ridging bodies, celery banking equipment or deep ploughs are being compared with strawing-over.

Some prefabricated alternatives to strawing down bed grown carrots are being studied. These include types of 'pillow' made from polythene/corrugated paper/builder's paper and extruded and granular polystyrene. A urea/formaldehyde resin foam as used in cavity wall insulation is another possibility. Apart from recording their durability and effectiveness as 'insulators' their cost will be compared with the reputed £100 per acre overall cost for covering with straw and its subsequent disposal.

In 1969 it is hoped to erect outdoor ventilated storage in collaboration with the N.V.R.S. and the Electricity Council. Improved techniques of insecticide application for carrot fly control, and phased sowing and harvesting for the production of finger-type carrots will be included in the experimental programme.

Celery

A start has been made with studies of celery production. An excellent crop of Lathom Blanching was produced in a close spacing trial. The comparisons were between 6, 9 and 12-in. within-row spacings planted on 12 in.

rows. These spacings will be combined with variable irrigation treatments in future experiments.

Cold storage of celery to extend the marketing period is being undertaken in conjunction with the Norfolk N.A.A.S. Nine varieties including Fenlander and selections of New Dwarf White were grown both as a trench crop and close planted, and were lifted into store on three dates in October and November. At three withdrawal dates during January to March, sample crates will be examined for the development of storage rots and weight losses. Variety testing will continue to assess the merits of blanched and 'green' seed stocks.

DRYING AND STORAGE OF BULB ONIONS

J. D. Whitwell, *Kirton Experimental Horticulture Station*

Onions in bulk have been stored successfully from mid-September to March at Kirton E.H.S. during the past four years. The store used for the purpose is an un-insulated building of dimensions 27 × 30 ft; it is equipped with a fan of 20 h.p., which will deliver 12,000 c.f.m. at 5 in. W.G. and 18,000 c.f.m. at 2 in. W.G., and heater banks 2 × 9 kW and 1 × 18 kW. The main duct runs along the length of the building and measures 6 × 3 × 30 ft. Interlocking 'Expamet' metal laterals, 5-ft in length, run along the concrete floor at 3-ft centres. The onions (90 tons approximately) are stacked 8 ft high.

The onions are windrowed for 7 days in the field and brought into bulk store with their tops on; this hastens the drying process and also reduces the risk of neck-rot. Small bulbs and as much trash and soil as possible are removed before loading, and the drying process commences as soon as a reasonable section of the store is filled. Great care is taken to minimize damage to the bulbs during lifting from the field and loading into the store.

Assuming that the store is filled with 90 tons of onions, the fan is capable of delivering 200 c.f.m. air per ton. The Canadians recommend 105 c.f.m. air per ton, and the Dutch between 120 and 170. Larger air flows are not a disadvantage, and enable the store operator to dry the onions fairly quickly, and bring the stack temperature down rapidly during cold nights from November to March.

Heater banks allow heat to be provided in stages, and on the grain drying installation at Kirton we can provide 250, 500, 750 and 1,000 B.t.U.s per hour per ton on 120 tons stored; in 1968 with 90 tons in store the heater banks provided 340, 680, 1,020 and 1,360 B.t.U.s per hour per ton. When the fan air inlet is closed a certain amount of re-circulation is possible and this helps to build up temperatures during the drying process, and at the same time prevents the relative humidity in the main air duct from falling below 60 per cent.

When the onions are loaded, air at ambient temperature is blown through for a period of time—4–6 hours—and then the air is warmed by turning

on the heater banks at intervals of 4–6 hours so that after a period of 24 hours the full heat load is being applied. Approximately half way through this process the inlet louvres to the fan are closed so that outside air is excluded, and the air is re-circulated from the fan, through the onions, into the store atmosphere, and back through the onions again. The temperature of the duct air and the onion stack gradually rises, and at the same time the relative humidity of the air falls. The R.H. is not allowed to fall below 60 per cent if possible, but should this occur a heater bank is turned off or the inlet louvres are opened to lower the temperature. This means that the temperature can only rise to a certain level in a store which has no humidity control.

With the large air flow available at Kirton we are able to dry the onions successfully in 3–5 days at a maximum temperature of 23·9°C (75°F), and with the stack temperature fluctuating between 5·6° to 11·1°C (10–20°F) above ambient during the drying period. The average R.H. of air in the main air duct during this period is above 60 per cent, but this also fluctuates. Skill is needed to dry the onion skins without splitting, and success is dependent on a knowledge of varieties, good temperature and humidity measurements in the main duct, and temperature measurements in the onion stack. The onions are dry when their outer skins rattle and their necks are tight and withered like dried grass; the skin colour during the drying process deepens to a honey-gold.

Once the onions are dry it is only necessary to keep them warm and dry during September and the early part of October—this is achieved by blowing ambient air through the stack. After mid-October the onions should be cooled gradually by operating the fan when the temperature outside is at least 1·7 to 2·8°C (3–5°F) below the stack temperature. When the stack is 5·6°C (10°F) higher in temperature than the outside air, it is possible to operate even at 95–100 per cent R.H. without water condensing on the onions. During November, December and January the stack temperature should be in the lower 40s°F (about 5°C) or upper 30s°F (about 3°C).

The storage life of onions can be extended by using the sprout inhibitor maleic hydrazide. This is applied at 4 pints per acre at 60 per cent die-down in the field, and onions so treated will remain dormant for long periods and their storage life is extended to 8–9 months. In experiments at Kirton we have kept treated onions until June with no difficulty.

The cost of drying and keeping the onions until 4 December, are calculated as follows:

	£	s.	d.
Fan consumption for drying (96 hours)—1,440 units	10	8	0
Heater bank consumption for drying—2,619 units	18	18	0
Total cost of drying	29	6	0
Cost of keeping and cooling to 4 December	113	6	0
Total cost of drying and storing until 4 December	142	12	0
Cost per ton on 90 tons to 4 December	1	12	0

METHODS OF RAISING EARLY SUMMER CAULIFLOWER PLANTS

J. D. Whitwell, *Kirton Experimental Horticulture Station*

Plants of the early summer cauliflower varieties Romax Early and Delta were overwintered in various ways during the 1967–68 season to see if the costs of raising in 3½-in. clay or 3-in. plastic pots could be reduced without losing the advantages of high yields, earliness and head quality.

The table below lists the methods used and shows the comparative yields, date of maturity and percentage heads in Class 1 and Extra grades.

Plant raising method	Date of 50% Maturity		Yield in crates/acre		% Extra + Class 1		% Buttons	
	Romax	Delta	Romax	Delta	Romax	Delta	Romax	Delta
	June	*June*						
3½ in. clays, J.I.P.1	2	13	347	971	78	73	62	0
3½ in. clays, J.I.P.1 minus hoof and horn	1	14	497	998	86	80	44	0
3 in. plastic pots	1	12	449	992	85	77	50	1
Drawn plants overwintered in closed frames	13	20	843	892	89	85	6	2
Drawn plants overwintered in ventilated frames	16	20	683	937	87	75	8	0
2¼ in. × 2¾ in. whalehide tubes (perforated)	12	18	637	955	82	77	26	1
2¼ in. × 2¾ in. whalehide tubes	9	19	622	952	88	77	32	0
1¾ in. × 2¾ in. whalehide tubes (perforated) Jan. sown	20	23	828	909	94	79	0	0
1¾ in. × 2¾ in. whalehide tubes, Jan. sown	20	23	792	932	82	70	0	0
Mean	10	18	633	949	85	77	25	0·4

Details of Plant Raising Methods

Container grown plants (excluding January sown)

Sown 6 October, 1967 in standard seed trays, 300 seeds per tray in J.I.P.1. After pricking out on 17 October, the pots were stood in chitting trays and overwintered in cold frames. Planting was on 11 March, 1968.

Plants raised in cold frames

Two double-span Dutch lights of each variety were sown on 6 October, 1967, with a Snild drill set to space the seeds 3 × 1 in. apart. 2 single lights of each variety were ventilated throughout the winter, and 2 were kept closed from seed sowing until planting out on 11 March, 1968.

Container grown plants (January sown)

These treatments were sown on 15 January, 1968 in seed trays, 300 seeds per tray and pricked out on 8 February into small whalehide tubes. Mild heat was given at night for the first 4 weeks after sowing. Planting was on 10 April.

All seedlings were given a full dichlofluanid spray programme against mildew, and all were treated with sodium molybdate as a precaution against deficiency.

Results (see Table)

Romax Early was considerably earlier in reaching the 50 per cent maturity date in $3\frac{1}{2}$-in. clay and 3-in. plastic pots than the variety Delta, but unfortunately this variety produced a high proportion of buttons in these large containers and this lowered the yield considerably. The number of buttons was lower with Romax Early grown in J.I.P.1 minus hoof and horn meal, but this result is opposite to that of the previous year's experiment. The marketable heads were ready for cutting extremely early and were of very good quality.

Delta grown in these large containers gave very high yields, no buttons and a high percentage of Extra and Class 1 heads; however, it was no earlier than Romax Early grown as drawn plants in closed Dutch light frames which also gave high yields and excellent quality.

Romax Early grown in the larger of the whalehide tubes ($2\frac{1}{4} \times 2\frac{3}{4}$ in.) packed closely in potato chitting trays (approximately 100 per tray) gave a satisfactory yield, a tolerable proportion of buttons and heads of very good quality which were earlier than Delta grown in $3\frac{1}{2}$-in. clays and 3-in. plastic pots. This treatment was about the optimum for yield, quality and earliness and was achieved in low cost plantable containers. Delta grown in the same containers was 6–10 days later than Romax Early but produced yields and quality comparable to Delta grown in $3\frac{1}{2}$-in. clays and 3-in. plastic pots. The $2\frac{1}{4} \times 2\frac{3}{4}$-in. tubes were perforated to see if this led to better rooting and quicker establishment after planting, but in 1968 this did not occur and the cost of making the perforation was not justified.

Delta and Romax Early grown in the small whalehide tubes ($1\frac{3}{4} \times 2\frac{3}{4}$-in.) were sown in January and this treatment is therefore not strictly comparable with the others which were autumn sown. The treatment was successful because of the low cost of propagation and the high yields and quality heads obtained from both varieties. This system is complementary to the others because it extends the season of high quality heads produced from containers, but in this experiment it had no advantages over well grown drawn plants, autumn sown in frames, which were cheaper to produce.

Romax Early and Delta sown with a small precision drill in rows in Dutch light frames in the autumn of 1967 to stand 3 × 1 in. gave very good results, particularly in yield and quality. The date of maturity followed

those plants grown in the larger whalehide tubes. Romax Early grown in the closed frames was earlier and gave a higher yield than in the ventilated frames. Delta produced heads of better quality from the closed frames. Drawn plants sown in frames and not pricked out and not ventilated are the cheapest to produce.

Conclusions

Romax Early on average proved to be 8 days earlier than Delta. Plants of both varieties grown in $3\frac{1}{2}$-in. clays and 3-in. plastics matured earlier than the other treatments, but Romax Early produced a high proportion of buttons when grown in these containers. The larger plantable whalehide tubes were next in earliness, then the drawn plants, and finally the January sown plants raised in lettuce tubes.

The optimum result for earliness and quality was achieved with Romax Early grown in the $2\frac{1}{4} \times 2\frac{3}{4}$-in. whalehide tubes, these gave a better yield than the same variety grown in $3\frac{1}{2}$-in. clays or 3-in. plastics, and were earlier than Delta grown in any container. Possibly the best achievement was with Romax Early grown as drawn unpricked-out plants in closed Dutch light frames which gave a high yield, above average quality and were as early as Delta grown in $3\frac{1}{2}$-in. clay pots. This demonstrates that it is possible to achieve both earliness and high yields with lower cost methods of propagation.

SEED DENSITY FOR MEDIUM SIZE EARLY BEETROOT

Jean M. Garthwaite, *Luddington Experimental Horticulture Station*

Small trials have been carried out for two years, at Luddington, to find the best rate of sowing to give a good yield of early beetroot of medium size.

The variety used was Detroit Improved Globe rubbed and graded seed. In the first year, 1967, germination and subsequent growth were poor so in 1968 thiram treated seed was used and early growth was very good.

In 1967 the grade of 'seed' used was $\frac{11}{64}$ to $\frac{15}{64}$ in. averaging 2·2 seeds per cluster with 28,000 clusters per lb. A laboratory germination test produced 107 seedlings per 100 clusters of 48·5 per cent seed germination. In 1968 the grade of seed was $\frac{7}{64}$ to $\frac{11}{64}$ in. (M-T grade) with 1·4 seeds per cluster and 36,000 clusters per lb. The laboratory germination was 57 seedlings per 100 clusters or 40 per cent seed germination.

Each year the seed was drilled on 15 March using a belt selector seed drill and drilling six 10-inch rows on a bed system. Different belts were used to achieve different sowing rates which varied from 10·2 lb to 43·1 lb seed per acre. The resulting plants per square foot varied from 3·8 to 10·6 in 1967 and 6·6 to 23·9 in 1968.

Each year the plots were sub-divided for three harvest dates at weekly intervals from the beginning of July to mid-July. In 1967 yields were low due to poor growing conditions but there were no significant differences in

marketable yield between the four sowing rates used and there was an increasing amount of unmarketable undersized beetroot as the sowing density increased. In 1968 yields were good and increased with the later harvest dates. The lowest sowing rate gave the earliest yield so that at each harvest the greatest marketable yield and the lowest percentage of small unmarketable beet came from the lowest density. The marketable beetroot was between $\frac{3}{4}$ in. and $2\frac{1}{4}$ in. in size.

In both seasons, therefore, the lowest rate of sowing was the most economical and whereas for maincrop beet the optimum density is around 12 per sq. ft, 1968 results suggest that for an early yield no higher than 7 per sq. ft is desirable.

ANEMONE CORM PRODUCTION

A. Elizabeth Jeff and H. J. Eaton
Rosewarne Experimental Horticulture Station

The majority of anemones grown in the open as a winter flower crop in south-west England, are grown from corms imported annually from Holland. During recent years the strains of anemones in general use have shown an increased susceptibility to winter damage, either due to a deterioration in frost and disease resistance or to slightly more severe winter conditions. A breeding programme to obtain hardier strains has been in progress at Rosewarne E.H.S. during the past eight years. The first field trials on commercial holdings of these strains is taking place this season (winter 1968-69) and it is hoped that these trials will confirm the results obtained in previous years on the Station.

During the past four years the techniques required for the production of corms on a field scale in Cornwall and the Isles of Scilly, have also been investigated. Soil preparation, sowing rate, weed control and harvesting techniques have all been studied, and machinery is being developed both for sowing the seed broadcast on 4-ft wide beds, and for harvesting the corms.

Because the corms are only from 1–2 cm to 4–5 cm in circumference when mature, they can only be economically harvested from light sandy soils that are easily sieved through a $\frac{1}{8}$-in. sieve. Small areas of suitable soils are present in West Cornwall and on the Isles of Scilly, and with the co-operation of local growers in Cornwall and the N.A.A.S. Demonstration Station on the Isles of Scilly, we have carried out field trials on these soils for several years.

A harvesting machine has now been developed which is also used to remove all small stones and clods from the top 2–3 inches of soil before the seed is sown. When the corms show signs of maturity in July or August, the tops are burnt off by flame gunning and the corms lifted with the harvester direct into boxes. By using a bed system, the formation of clods within the sown area is avoided and the corms harvested this year under less than ideal conditions contained very few small clods or stones.

The breeding programme and the study of corm raising techniques are continuing and it is hoped that both will be ready for large scale production in 2 to 3 years.

New Items of Interest in the Experimental Programme

MIXING TO MAINTAIN THE PRODUCTIVITY OF PEAT SOILS

Since the first large scale drainage of the peat fens three hundred years ago, wastage of the peat through oxidation and erosion has converted one third of the original 345,000 acres of drained fen into skirtland. Here the peat remnants are coming within plough depth and are being mixed haphazardly with the underlying clays, silt alluvia and sandy gravels.

As this wastage and mixing continues, farmers of the black fen have to face three major problems. Firstly, there is the loss of the very amenable topsoil upon which the successful cultivations necessary for the high value cash crop systems of the fens depend. Secondly, the shrinkage of the profile brings the ground water table nearer to the surface causing new drainage problems, necessitating in some areas the laying of new drainage systems within the mineral subsoil, and finally, successive ploughings will unevenly introduce into the rooting zone quantities of acid 'drummy' peat and unweathered mineral subsoil, varying in texture from coarse sand to silty clay. As the proportion of subsoil increases in the cultivation layer, nutrient status, pH and soil management problems may arise.

The Arthur Rickwood Experimental Husbandry Farm is investigating methods of mixing the remaining peat topsoil where its thickness is eighteen inches or more, with varying proportions of the mineral subsoil. By this means it is hoped to reduce wastage by distributing the peat throughout a greater profile depth and to increase the rooting zone of the crop, by breaking down the barriers to root penetration at the zonal interfaces and so produce an even loamy topsoil to three feet.

In 1967 a three-bladed mixing subsoiler, developed by Dr. A. N. Ede of the Unit of Land and Water Management Research, became available and work in the immediate future will study the use of this implement on a wide range of peat/subsoil profile types, both on the Experimental Farm and also on sites made available by farmers in the area. It is hoped that other implements, in particular a deep working rotary type, will in time become available for investigation.

Regional Soil Scientists are co-operating in studying the productivity, moisture and drainage characteristics, nutrient status, microbiological activity and workability of the mixed soils, under the usual range of crops grown in the area.

The wastage rate of the mixed soil profile will also be measured and compared with undisturbed profiles at each site.

Two sites have been selected on the E.H.F. One has 14–17 in. of sandy peat overlying compacted fine sand. The soil mixing treatments have been applied and N, P and K treatments have been carried out on the first test crop, potatoes. The second site has 15–18 in. of peaty loam over silty clay loam and has carried a preliminary study only, up to now. It is hoped to begin the full-scale mixing trial there in the autumn of 1969.

If this technique proves to be a success agronomically it must be acceptable economically to the farming community both in the short and in the long

term. For this reason the economics of the whole operation is also being carefully monitored.

J. Smith

EFFLUENT DISPOSAL EXPERIMENTS

The rapid intensification of livestock enterprises has greatly increased the quantity of slurry produced and highlighted the disposal problem. In most cases spreading slurry on the land offers the only economic method of disposal. The question is how much slurry can be applied without adversely affecting future crop production?

Experiments have commenced at Bridget's, Great House and Trawscoed E.H.F.s to investigate the effect on soil conditions and subsequent crops of applying large quantities of slurry during the winter. Cow and pig slurry are being applied in separate experiments to examine any difference arising from the source of slurry. Experiments using pig slurry are in progress at Great House and Trawscoed where a number of application rates over the range 45,000 to 320,000 gallons per acre of 1:2 diluted pig slurry are being tried. These rates correspond to the annual slurry production from 40 up to 300 bacon pigs applied to one acre. At Bridget's and Trawscoed cow slurry is being applied at number of application rates over the range 30,000 to 240,000 gallons per acre of 1:3 diluted cow slurry. This is equivalent to the annual slurry production from 2 up to 16 cows applied to one acre. The total quantity for each application rate is divided into a number of equal sized dressings which are being applied at fortnightly or monthly intervals through the winter. At all farms the slurry is being applied to grassland, which will be cut for conservation. In addition at Bridget's, cow slurry is being applied to land which will be cropped with potatoes. All experiments include a control treatment which will receive inorganic fertilizer in the spring at an optimum rate for the crop concerned. At Great House and Trawscoed the slurry is being applied to small plots while at Bridget's it is being applied by a commercial organic irrigation system, using much larger plots.

At Bridget's there is a small subsidiary experiment investigating cultivation or weekly application in an attempt to prevent the surface run-off of slurry which occurs with organic irrigation systems when large quantities of slurry are applied at one time.

Full records are being kept of the quantity and nutrient content of the slurry applied and of the production from the various treatments. Detailed examinations of the soil and soil fauna are also being carried out. Where possible drainage water from each treatment is being collected and its Biochemical Oxygen Demand determined to measure the level of pollution present.

These experiments will continue for a number of years to determine the long-term effect of high rates of slurry application.

H. T. H. Cromack

PLANE OF NUTRITION FOR BEEF CALVES

The criteria to be used in assessing the value of any calf-rearing system should take into account the life-time performance of the animal. Many

experiments in which different methods of rearing are compared, result in small differences in performance which are very soon lost in later life due to variations in grazing and feeding regimes. Consequently current knowledge and the targets applied to rearing systems are not entirely proven.

It is generally agreed that a difference of at least 50 lb liveweight at three months of age is necessary in order to detect any significant differences in subsequent performance. The Plane of Nutrition experiment is designed to compare the performance of beef calves reared at two different growth rates to achieve this difference of 50 lb in the first three months of life, and then to follow their subsequent production as either barley beef (Rosemaund) or 18-month-old beef (Liscombe). Rearing at a low level of 1–1¼ lb daily liveweight gain is being compared with rearing at a high level to get maximum possible gain of the order of 2 lb per day to 12 weeks old. The low level group will be weaned off milk substitute when the dry concentrate intake per animal is 1½ lb per day and from then on hay will be supplemented by up to 3 lb concentrates per head per day. The high level diet will be based on *ad lib* milk substitute and concentrates with a restricted hay intake.

At Liscombe an 18-month beef finishing system will be followed, and in the 3–6 months old stage further high and low levels of feeding will be compared before turnout to grass. The animals will be fattened on similar rations in their second winter.

At Rosemaund the fattening stage will begin immediately after the animals are 12 weeks old and will be on a barley beef system.

A. Yule

ZERO GRAZING FOR BEEF CATTLE

Production from heavily fertilized grassland grazed at high stocking rates by young beef cattle is often limited by refusal to eat grass fouled by dung and urine, or smeared with soil by frequent treading. There is also the danger of a rapid build-up of stomach worms. In the spring of 1968 preliminary trials were started at Drayton and High Mowthorpe to see whether these problems could be overcome and a greater output per acre achieved by zero grazing. At both centres yarded cattle were fed freshly-cut grass daily throughout the season, but in the second half of the season performance was no better than that of grazing animals. This appeared to be due to a low intake of herbage dry matter. Methods of increasing intake will be studied in future trials.

The value of supplementary feeding of rolled barley either throughout the season at three pound per head per day (High Mowthorpe), or as required to maintain two pound liveweight gain per day (at Drayton), was also investigated. Both methods improved growth rates but the second method was more economic.

There are many additional costs incurred with a zero grazing system, not least of which are those of straw bedding and manure disposal. The possibility of feeding cut grass out of doors will, therefore, be tried at High Mowthorpe.

J. Rablah

CREEP FEEDING AND POST-WEANING MANAGEMENT OF LAMBS

Following the earlier experiments described (see page 64), further work is in progress at Liscombe with the aim of reducing the large numbers of store lambs, often of poor quality, which are produced in marginal and upland areas in the south-west.

In 1968 a trial was started to investigate the value of concentrate feeding for lambs from a very early age. Lambs from Welsh Mountain and Welsh half-bred ewes were fed concentrates from birth right through to weaning.

At lambing, half the twin and single lambs were allowed access to concentrates through a creep fence, and grazing was on a rotational basis within an intensive sheep monoculture unit.

The lambs were sold as stores, and the effect of concentrates was to increase marginally sale weight and value, and to advance the date of sale by 4–8 days when compared to similar lambs that had not received concentrates. These effects were more obvious with twins than single lambs. However, since concentrate consumption amounted to between 32 and 53 lb per lamb, the slight increase in the sale value of the lamb was insufficient to pay for the cost of the concentrates used, and thus concentrate feeding reduced the margin of sales over concentrates by an average of 13s. per lamb.

It is possible, however, that there are some indirect benefits obtained from feeding concentrates before weaning to lambs. The percentage of ewes culled after lambing was less (23 per cent as against 29 per cent) where lambs had received concentrates, and this was probably due to the fact that more grass was available for ewes, and less strain was imposed on the ewes due to less demand for milk. This trial is to continue and the possible benefits to the ewe examined more closely. In addition half the lambs will be sold on a deadweight basis.

A trial has also been running for two years examining the value of supplementary concentrate feeding to weaned lambs when fattened on a number of pasture types. These were: stale pasture, which had sheep running on it before weaning; a fresh aftermath, which had not carried sheep since the silage or hay cut; very fresh aftermath, which had not carried sheep during the current year; and rape with a grass run back. The lambs were sold at monthly intervals when they were judged to be fat.

The effect of concentrate feeding has been to speed up the rate of sale, and the final number sold fat. Also the sale weight and killing-out percentage have been slightly improved. On the poorer pastures (stale or fresh aftermath) the cost of concentrate feeding ewes was slightly greater than the increased value of the lambs. The cost of concentrate feeding was therefore not directly repaid. But a greater proportion of lambs were sold fat and so obtained a guaranteed price. On the better fattening pastures (very fresh aftermath and rape) the increased value of the lambs did not equal the cost of the concentrate used, and the margin of sales over concentrate costs was considerably lower when concentrate was fed. This trial is to continue for a further year.

M. Hastings

BEANS IN PIG RATIONS

The increasing interest in the use of field beans as a break crop in systems of intensive cereal growing has led to an estimated harvest of 250,000 tons of beans in 1968. Further expansion is forecast and if the proposals of the Economic Development Committee for Agriculture are fulfilled production will reach 500,000 tons in 1973.

A co-ordinated trial was therefore started in 1968 at Great House, Terrington and Trawscoed Experimental Husbandry Farms to investigate the percentage of bean meal which can be used in rations fed to bacon pigs. The trial compares four rations which are formulated so that all have similar crude protein contents. Each ration is in two parts, an A ration which is fed up to 120 lb liveweight and a B ration which is used thereafter.

Treatments (*percentage composition of rations*)

	1		2		3		4	
	A	B	A	B	A	B	A	B
Barley	77½	81¼	68¼	72	78¼	80	69	80
Weatings	15	15	15	15	0	0	0	0
Fish meal	7½	3¾	3¾	0	3¾	0	0	0
Beans	0	0	13	13	18	20	31	20
Crude Protein	15·1	13·0	15·07	13·1	15·0	13·2	15·0	13·2

Groups of 6 to 10 Large White weaners are started on test at up to 10 weeks of age. They are trough fed twice daily and two pints of water are added to each pound of meal, with water bowls also available. The pigs are rationed according to liveweight but limited to a maximum of 6 lb of meal per day.

One lot of Minor tick beans was purchased to supply all three E.H.F.s as this variety has the highest protein content of those commercially available. Samples taken at Terrington had an average crude protein content of 28 per cent. Other ingredients are purchased locally but the same proprietary brands of fish meal and vitamin and mineral supplement are specified. Also the weatings must contain not more than 7 per cent fibre.

The experiment is still in progress but results from the first replicates on trial suggest that up to 30 per cent of beans may be successfully used in rations for fattening pigs. All the rations were readily eaten at Great House and Terrington and no difference in palatability was noted. At Trawscoed the ration containing 31 per cent beans was not eaten as readily as the other rations.

A. Lightfoot

THE PRODUCTION AND USE OF HEALTHY RHUBARB CLONES

For many years the widespread presence of virus in commercially important stocks of rhubarb in this country has been suspected, but a detailed study of rhubarb viruses was only begun in 1963. Earlier work reported in the literature had been largely concerned with the description of specific transmissible leaf disorders of rhubarb but the more recent studies have been aimed at the identification of the causal agent.

Of the three most widely grown forcing varieties Prince Albert and Victoria originated in the first half of the nineteenth century, while Timperley Early was introduced in the first half of the present century. Propagation is entirely by vegetative means and the common rotation on rhubarb holdings in the main forcing area involves the repeated cropping of the land with rhubarb with very few break crops. Such conditions are probably ideal for the spread of virus diseases and all plants of these varieties on commercial holdings are believed to be infected.

By transmission to a range of indicator hosts and by purification and electron microscopy, five virus disorders have so far been identified in British stocks of rhubarb. Distinct strains of at least one of these viruses occur. Multiple infection of the plants has frequently been found and the viruses present have all been reported as infecting other crop plants and include the widely occurring turnip mosaic virus and arabis mosaic virus. The viruses fall into two groups—those typically aphid transmitted and those which are normally soil borne. Definite proof has been obtained of virus transmission in rhubarb by *Myzus persicae* and *Aphis fabae* and is probable that free living eelworms play a part in the spread of those soil bourne viruses which infect rhubarb. Just under 10 per cent of Prince Albert seedlings raised from seed collected from open pollinated plants were found to be infected with cherry leaf roll virus. It is just possible that some commercial varieties may stem from seedlings which have always been infected.

It is reasonable to assume that varieties of lasting commercial importance have been selected largely because of their high degree of virus tolerance. There is, however, some evidence to show that virus freedom will result in an increase in vigour of these tolerant varieties. Less tolerant varieties which at present have no commercial importance, although they are of high quality, may become of interest when laboratory treatments have freed them from virus infection.

Small stocks of virus-free rhubarb of six varieties have been raised by meristem culture at the National Vegetable Research Station and initial trials have been planted to compare healthy material with commercial stocks and to study the rate of re-infection of the plants.

The fact that it has proved possible to select a few healthy plants from basically infected stocks of some of the less widely grown rhubarb varieties suggests that it will be possible, with care, to maintain virus-free clones in a substantially healthy condition in the field for some years. However, in unfavourable conditions re-infection can occur almost immediately.

Studies are in progress of methods for the rapid multiplication of healthy material aimed at enabling the industry to benefit from research findings with the minimum of delay.

M. W. Case

COILED SPROUT OF EARLY POTATOES

It has been observed that 'coiling' of individual shoots of early potatoes (see Plate VII) in the early stages of growth after planting can delay emergence by one to two weeks, and very often secondary growth is stimulated below the malformed sprout. The disorder may appear as a simple coil, or in addition the distorted stem may be thickened, grooved or even split.

It is thought that this disorder results from planting physiologically mature seed which has been stored in warm conditions. The incidence may well be encouraged in seasons when soil temperatures at or after planting are low. Work at Sutton Bonington has shown that one of the most important factors contributing to the maturity of the seed is storage temperature during chitting. With this factor in mind, an experiment was begun at Rosewarne in the autumn of 1967 to determine the effect of storage treatments both on the incidence of coiled sprout and on yield.

Two varieties were compared, Home Guard which is fairly widely grown in West Cornwall, but which is apparently not particularly prone to coiling and Arran Pilot, a very susceptible variety. The seed used was grown at Rosewarne, lifted in late August and stored in an open barn until the end of October when storage treatments commenced. Storage of the seed was in controlled cabinets at the following temperatures, 4·4°C (40°F), 10°C (50°F), 15·6°C (60°F) with 12 hours light until 31 January 1968, then 14 hours light until planting. For comparison, seed was stored in a chitting house in normal daylight with fluctuating temperatures but with a minimum set at 4·4°C.

All treatments were planted on 29 February when the soil temperature at 4 in. was 3·0°C (37·5°F). There were three lifting dates at weekly intervals, commencing on 6 June, when weights of ware and chats and the presence of coiling in shoots on each tuber were recorded.

Results obtained in the first year of this experiment showed that while storage at the lowest temperature induced multi-sprouting, there was little or no coiling; at higher temperatures however fewer sprouts per set were produced with some coiling. There was more coiling of sprouts with Arran Pilot than in Home Guard at all temperatures, none being recorded in Home Guard stored at 4·4°C either in the controlled temperature cabinet or in the chitting house.

Storage at 4·4°C, while producing the least coiling, also led to later emergence and delay in bulking; the bulking rate with the higher storage temperatures was however satisfactory. Yields from tubers stored in the chitting house compared favourably with those under strict warm temperature control. From warm storage treatments of both varieties, yields were almost always considerably better than at a controlled 4·4°C.

Thus, although these early results have shown some evidence of a temperature effect on the incidence of coiling, this does not appear to be directly related either to rate of bulking or yield. This experiment is to be continued and it is hoped that it will be possible to establish more clearly the relationship between the temperature at which tubers are stored and the incidence of coiled sprouts. *L. M. Gill*

Experimental Husbandry Farms and Horticultural Stations

Centre	*Acreage*	*Main Farming and Experimental Activities*
Arthur Rickwood E.H.F. Mepal, Ely, Cambs.	150	Arable farm on peat soils of varying depth. Studies on peat wastage. Cash crops, including potatoes, sugar beet, vegetables and cereals.
Boxworth E.H.F. Boxworth, Cambs.	858	Cereal and dairy farm on boulder clay. Intensive cereal cropping, manuring, weed control. Break crops including beans. Feeding and management of Friesians for milk and beef.
Bridget's E.H.F. Martyr Worthy, Winchester, Hants.	1,035	Mixed farm on chalk. Cereals: intensive cropping and manuring. Break crops. Leys: fodder conservation and herbage seed production. Large Friesian herd; management and feeding studies. Intensive management of sheep.
Drayton E.H.F. Alcester Road, Stratford-on-Avon, Warwicks.	450	Mixed farm on Lias clay. Cereals: intensive cropping; winter beans. Fodder conservation. Beef cattle: grazing, feeding and calf-rearing. Cross-bred sheep: winter housing of ewes, intensification on pasture.
Gleadthorpe E.H.F. Welbeck Colliery Village, Mansfield, Notts.	493	Light sand arable farm. Cereals: intensive cropping, manuring; potatoes, sugar beet, carrots and other cash crops; irrigation. Feeding and grazing of Friesian beef cattle. Poultry: feeding and management.
Great House E.H.F. Helmshore, Rossendale, Lancs BB4 4AJ	460	High-lying Pennine farm in industrial area. Grassland production and utilization. Feeding and management of Friesian cattle, Gritsone sheep and Large White pigs.
High Mowthorpe E.H.F. Duggleby, Malton, Yorks.	1,080	Mixed farm on high-lying chalk. Cereals and seed potato growing. Leys: grazing and fodder conservation. Single suckled and artificially reared beef cattle; cross-bred sheep.

Centre	*Acreage*	*Main Farming and Experimental Activities*
Liscombe E.H.F. Dulverton, Somerset.	495	Upland grass farm adjoining Exmoor. Manuring and management of grass, fodder conservation. Rearing and feeding single-suckled and artificially reared cross-bred beef cattle; intensive sheep grazing.
Pwllpeiran E.H.F. Cwmystwyth, Aberystwyth, Cards.	3,100	Mountain farm. Welsh Black and cross-bred suckler cattle: Welsh mountain sheep: methods of wintering, feeding, flock management and cross-breeding.
Redesdale E.H.F. Rochester, Otterburn, Newcastle-upon-Tyne.	3,832	Pennine hill farm. Blackface sheep, Galloway and cross bred suckler cows. Management of stock: more intensive stocking and provision of fodder.
Rosemaund E.H.F. Preston Wynne, Hereford.	435	Mixed farm on heavy red sandstone soil. Cereals, cider apples and hops. Grazing and feeding cross-bred beef cattle and sheep. N.I.A.B. Regional Trial Centre.
Terrington E.H.F. Terrington St. Clement, King's Lynn, Norfolk.	200	Silt land arable farm. All aspects of potato production, also sugar beet, beans, peas and cereals. Large White pigs. N.I.A.B. Regional Trial Centre.
Trawscoed E.H.F. Trawscoed, Aberystwyth, Cards.	808	A mixed farm on shale soils with moor. Rearing, feeding and management of Friesian dairy cattle and cross-bred suckler beef cattle; Welsh and half-bred sheep and Large White pigs. N.I.A.B. Regional Trial Centre.
Cleppa Park E.H.S. Newport, Monmouthshire NP1 9YT.	68	Production of soft fruit, vegetable and flower crops under local conditions in the open, and under glass.
Efford E.H.S. Lymington, Hampshire SO4 0LZ.	376	Trials with top and soft fruit; vegetables including early potatoes; glasshouse crops including tomatoes, lettuce; flower crops; irrigation.
Fairfield E.H.S. Greenhalgh, Kirkham, Preston, Lancs. PR4 3HH	22	Glasshouse crops including tomatoes, lettuce; flowers; mushrooms.

Centre	*Acreage*	*Main Farming and Experimental Activities*
Kirton E.H.S. Kirton, Boston, Lincolnshire.	104	Bulb flower crops including hot water treatment, storage and forcing; strawberries; vegetables, especially summer cauliflowers.
Lee Valley E.H.S. Ware Road, Hoddesdon, Herts.	26	Glasshouse crops including tomatoes, cucumbers, lettuce, chrysanthemums; flowers and some intensive vegetables in the open; mushrooms.
Luddington E.H.S. Stratford-upon-Avon, Warwickshire.	230	Apples, plums and soft fruit, pest and disease control, nutrition and rootstocks; vegetables; flowers; glasshouse crops; irrigation; weed control.
Rosewarne E.H.S. Camborne, Cornwall.	115	Bulb and other flower crops; vegetables, including early potatoes; mobile glasshouses; shelter; weed control
Ellbridge Sub-station, Hatt, Saltash, Cornwall.	5	The study of crops produced in the Tamar Valley.
Isles of Scilly Demonstration Station, Trenoweth, St. Mary's, Isles of Scilly.	3	Bulb crops.
Stockbridge House E.H.S. Cawood, Selby, Yorks.	161	Vegetable crops including rhubarb; top and soft fruit; crops and rotations for fixed and mobile structures; shelter; mushrooms; flowers.
National Fruit Trials, Brogdale Farm, Faversham, Kent.	185	Testing and classification of all types of top and soft fruit.

Norfolk Agricultural Stn. Morley St. Botolph, Wymondham, Norfolk.	434	This independent body collaborates with the Experimental Husbandry Farms in conducting various experiments. Medium loam soils. Intensive cereals, sugar beet, peas and potatoes. Feeding of cross bred beef cattle.

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